UNIVERSITY OF NIŠ

ISSN 1451-740X (Print)
ISSN 2406-0496 (Online)
COBISS.SR-ID 113549324
UDC 796/799

FACTA UNIVERSITATIS

Series
PHYSICAL EDUCATION AND SPORT
Vol. 20, Nº 1, 2022

Scientific Journal **FACTA UNIVERSITATIS**
UNIVERSITY OF NIŠ
Univerzitetski trg 2, 18000 Niš, Republic of Serbia
Phone: +381 18 257 095 Telefax: +381 18 257 950
e-mail: facta@ni.ac.rs http://casopisi.junis.ni.ac.rs/

Scientific Journal FACTA UNIVERSITATIS publishes original high scientific level works in the fields classified accordingly into the following periodical and independent series:

Architecture and Civil Engineering
Automatic Control and Robotics
Economics and Organization
Electronics and Energetics
Law and Politics
Linguistics and Literature
Mathematics and Informatics
Mechanical Engineering
Medicine and Biology
Philosophy, Sociology, Psychology and History
Physical Education and Sport
Physics, Chemistry and Technology
Teaching, Learning and Teacher Education
Visual Arts and Music
Working and Living Environmental Protection

SERIES **PHYSICAL EDUCATION AND SPORT**

Editor-in-Chief: **Zoran Milanović**, e-mail: *fupesed@junis.ni.ac.rs*
University of Niš, Faculty of Sport and Physical Education
Republic of Serbia, 18000 Niš, Čarnojevića 10a
Phone: +381 18 511 940, ext. 206. +381 63 7 399 366, Fax: +381 18 242 482

FACTA UNIVERSITATIS, Series Physical Education and Sport is indexed in Sport database SPORTDiscus, SPONET (Germany), DOAJ (Sweden), Serbian Citation Index (Serbia).

UDC Classification Associate: **Dijana Savić, Dubravka Dragić**, Library of Faculty of Sport and Physical Education, Niš
English Proofreader: **Marta Dimitrijević**, University of Niš, Faculty of Philosophy
The authors themselves are responsible for the correctness of the English language in the body of papers.

Secretary: **Olgica Davidović**, University of Niš, e-mail: *olgicad@ni.ac.rs*
Computer support: **Mile Ž. Ranđelović**, University of Niš, e-mail: *mile@ni.ac.rs*
The cover photo: **Prof. Dr. Aleksandar Kerković –** photo by Dragan Radojković
Publication frequency – one volume, three issues per year.
Published by the University of Niš, Republic of Serbia

Financial support: Ministry of Education, Science and Technological Development of the Republic of Serbia
Printed by ATLANTIS DOO, Niš, Serbia
Circulation 70

ISSN 1451-740X (Print)
ISSN 2406-0496 (Online)
COBISS.SR-ID 113549324
UDC 796/799

FACTA UNIVERSITATIS

SERIES **PHYSICAL EDUCATION AND SPORT**
Vol. 20, Nº 1, 2022

UNIVERSITY OF NIŠ

AUTHOR GUIDELINES

Dear authors,
It is mandatory to submit your original work by using our online manuscript submission system. You should select "New Submission" and upload your paper by using the online interface. All subsequent versions should be uploaded by using the same paper ID and your defined password. We are unable to process files sent by E-mail.
As an author, you are kindly advised to use our text format. This way no changes will be necessary in terms of paper and text format. Simply applying the styles defined in the document will be sufficient.
FU Phys Ed Sport copyright and warranty form will have to accompany your submission. Authors are responsible for obtaining any security clearances. All authors have to sign the copyright transfer form. The signed copyright form has to be scanned and uploaded by using the corresponding Supplementary files upload interface on the website.
The journal publishes original research articles, review articles and preliminary research reports contributing to knowledge about human movement in training and physical exercise.
A research article should report original research, presenting all the standard elements of a scientific investigation: the INTRODUCTION, METHOD (including participants, instruments and procedure), RESULTS, DISCUSSION, CONCLUSION, ACKNOWLEDGMENTS, REFERENCES and LEGENDS (Illustrations, Tables and Equations).
A review article is a critical evaluation of material that has already been published. A review article should include an analysis, evaluation, and synthesis and should not just be a reproduction of scientific facts. It is composed of the following sections: problem definition, summary of previous research, explanation of subject matter inter-relations, contradictions, problems and suggestions for further research. It includes the following sections: the INTRODUCTION, MAIN TEXT, CONCLUSION, ACKNOWLEDGMENTS, REFERENCES and LEGENDS (Illustrations, Tables and Equations).
A preliminary research report should present the findings of a research report, outlining all the standard elements of scientific investigation. It represents a short report on the completed part of an original research project which is still in progress. Reports of professional practices will need to demonstrate academic rigor, preferably through an analysis of program effectiveness, and should go beyond mere description. A preliminary research report includes the following sections: the INTRODUCTION, METHOD, RESULTS, DISCUSSION, CONCLUSION, ACKNOWLEDGMENTS, REFERENCES and LEGENDS (Illustrations, Tables and Equations).

GENERAL GUIDELINES

The article should be typed in a MS Word text editor, font Times New Roman and should not exceed 16 pages, including all parts of the article (title, abstract, main text, tables, illustrations and references). Author name, affiliation and complete address are to be placed underneath the title.

Language

The article must be in English. Authors from non-English speaking countries are requested to have their text thoroughly checked by a professional. Articles may be rejected on the grounds of poor English. Revisions regarding language errors are the responsibility of the author.
An ABSTRACT which does not exceed 250 words should be provided on a separate page. It should briefly describe the problems being addressed in this study, how the study was performed, the relevant results and what the authors conclude from the results, respectively. The abstract should be written in English and Serbian (a translation will be provided by the Editorial Board for non-Serbian speaking authors). The abstract should be a brief, comprehensive summary of the contents of the article (the problem, method, findings, including statistically significant levels, conclusions and implications).
Below the abstract: KEY WORDS, not more than 5 in total, accurately describing the contents of the manuscript. They should be written in English and Serbian.

TEXT

Introduction: this section should state the purpose of the paper, the reasons for the research and the relevant findings of prior research projects.
The Method section is usually divided into: the Sample of participants, Measures (Apparatus or Materials) and Procedures. The procedures (Procedures) should be described in such detail as to enable replication of the experiment and gathering of comparable data. Any statistical method must be outlined in detail in the participants and method section, and any methods not commonly used should be described fully or supported by references.

Results

Limit the number of tables and illustrations to a minimum and use them only as a qualification and support for your statements. Use graphs as an alternative to tables, but do not duplicate the information in tables and graphs. Define the statistical terms, abbreviations and symbols. All given units should be in accordance with the international metric system, and decimal points should be used. The results should be presented in the text, tables and illustrations in a logical order. Do not repeat the data from the tables or illustrations in the text, and present only important findings.

Discussion

Compare the results of the research with previous research projects. Connect the conclusion with the aims of the article, but avoid statements and conclusions that do not follow from outlined research. Emphasis should be put on

new and important aspects of the study and the conclusions that follow. Do not repeat data or other information given in the introduction or the results in detail. Connect the conclusions with the aims of the article, but avoid statements and conclusions that do not follow from your data.

Conclusion

A conclusion section must be included. Provide a succinct summary of the implications of findings as previously discussed that do not follow from the outlined research and your data.

Acknowledgements

An acknowledgements section may be added after the conclusion, if desired.

References

The method of writing references, quotations and citing references in the text should be according to the APA style (see: Publication Manual of the American Psychological Association, 6th Edition, 2010; see also: http://www.apastyle.org). This style of citation briefly identifies the source for readers and enables them to locate the source of information in the alphabetical reference list at the end of the article. Each reference cited in the text must appear in the reference list, and each entry in the reference list must be cited in the text. Make certain that each source referenced appears in both places and that the text citation and reference list entry are identical in terms of the spelling of the authors' names and the year.
For more details, please check our online guidelines:
http://casopisi.junis.ni.ac.rs/index.php/FUPhysEdSport/about/submissions#authorGuidelines

LEGENDS

Tables

Tables should be numbered consecutively and given a suitable caption. Tables should accompany the manuscript, but should not be included within the text. It should be stated clearly where they are to be inserted within the text (e.g., "Place Table 1 here"). Each table should be printed on a separate sheet. Tables should not duplicate any results presented elsewhere in the manuscript (e.g., in graphs). All the necessary explanations and a legend of the abbreviations have to be provided at the bottom of each table.

Illustrations

This category includes: photographs, schemata, diagrams, algorithms and other graphic material.
Photographs, charts and diagrams are all to be referred to as "Figure(s)" and should be numbered consecutively in the order in which they are referred to. They should accompany the manuscript, but should not be included within the text. All illustrations should be prepared by computer software, and each printed on a separate page. It must be made absolutely clear in the text where these illustrations should be included. All figures are to have a caption. Each illustration should have a number and a title. Legends to illustrations should be given at the foot of the illustration. If illustrations contain symbols, arrows, numbers or letters, these should be explained in detail in the legend.

Equations

When including equations, please simplify the complex formulas and check them carefully. Place short and simple equations in the line of the text, which should not project above or below the line. In articles where complex equations are a fundamental part of the manuscript and it is impossible to present their development in full, we advise that the authors present the missing parts in the form of a separate informal written communication to the reviewer. All special characters (where there might be doubt) should be accompanied by a note on the margin of the text.

REVIEWING

All manuscripts written in accordance with the instructions above will be evaluated via blind review by at least two reviewers. The reviewers are chosen by the editor. Assessments by the reviewers will be presented anonymously to the author and, if substantial changes are required, the article will be returned to the author for correction. The author shall again send the Board a corrected copy of the article, with a list of corrections on a separate page, again sending the article by e-mail.
The Editorial Board guarantees non-disclosure during the reviewing and publication process. The authors (co-authors) of the accepted articles shall receive one copy of the journal upon publication.
Journal web address: http://casopisi.junis.ni.ac.rs/index.php/FUPhysEdSport/index
Registration link: http://casopisi.junis.ni.ac.rs/index.php/FUPhysEdSport/user/register
Text format link: http://casopisi.junis.ni.ac.rs/files/journals/13/Tools/textformat.doc
Copyright and warranty form link: http://casopisi.junis.ni.ac.rs/files/journals/13/Tools/Copyrightandwarrantyform.doc

We would like to thank you for your interest in submitting an article to the journal Facta Universitatis, Series Physical Education and Sport.

FACTA UNIVERSITATIS

Series

Physical Education and Sport

Vol. 20, Nº 1, 2022

Contents

FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 20, No 1, 2022, pp. 1 - 12
https://doi.org/10.22190/FUPES211220001P

Research article

MIXED RESISTANCE TRAINING IMPROVES STRENGTH AND ANTHROPOLOGICAL CHARACTERISTICS IN YOUNG FEMALE ADULTS

UDC 796.015.52:612-055.2

Radomir Pržulj[1], Nebojša Čokorilo[2], Dušan Đorđević[3], Nebojša Trajković[3], Miloš Popović[4]

[1]Faculty of Physical Education and Sport, University of East Sarajevo
[2]Faculty of Sport, University Union – Nikola Tesla, Serbia
[3]Faculty of Sport and Physical Education, University of Niš, Serbia
[4]Faculty of Sport and Physical Education, University of Priština, Serbia

Abstract. *This study aimed to investigate the effects of ten weeks of mixed resistance training on isometric force parameters and anthropological characteristics in young female adults. Fifty-two participants (22.61 ± 1.86 years) were randomized into either the mixed resistance training (MRT; n = 25) or control group (CON; n = 27). Anthropological parameters were body mass, body fat percentage, skinfolds (triceps, tight, abdominal), while force parameters were the isometric force of hand flexors, upper-body flexors and extensors, and knee extensors (both legs). The MRT group was engaged in mixed resistance training consisting of four weeks of muscular endurance resistance training (ERT) followed by six weeks of traditional resistance training (TRT) three times per week. The CON group did not exercise. A two-way repeated measures ANOVA was used to determine the effects of programs on strength and anthropological characteristics. A significant group x time interaction was found for body fat ($p < 0.001$), waist-hip ratio ($p = 0.001$), triceps skinfold ($p < 0.001$), abdominal skinfold ($p = 0.001$), isometric force of right-hand flexors ($p = 0.001$), and isometric force of upper-body flexors ($p = 0.002$). No interaction was observed for body weight, thigh skinfold, isometric force of left-hand flexors, the isometric force of upper-body extensors, and isometric force of knee extensors. Mixed resistance training represents a valid training method to improve anthropological characteristics, but its role in isometric force was not fully confirmed in untrained females.*

Key words: *Strength Training, Body Weight, Force, Females*

Received December 20, 2021 / Accepted December 29, 2021
Corresponding author: Dušan Đorđević
Faculty of Sport and Physical Education, Čarnojevića 10a, 18000 Niš, Serbia
Phone: +381 18 510900 • E-mail: dusandjordjevic1995@gmail.com

INTRODUCTION

Physical activity has many health benefits (Bauman, 2004; Bogataj, Pajek, Ponikvar, Hadžić, & Pajek, 2020; Brady et al., 2016; Hyde, Conroy, Pincus, & Ram, 2011), and it has become an interesting research topic having in mind that inactivity is one of the main risk factors for disease development (Deslandes et al., 2009). It has been demonstrated that physical activity enhances brain plasticity and cognitive functioning (Colcombe et al., 2006; Kramer & Erickson, 2007).

To date, numerous studies were conducted on the effects of aerobic training, resistance training, and combined (aerobic + resistance) training (Orcy, Dias, Seus, Barcellos, & Bohlke, 2012; Wilson et al., 2012; Zambom-Ferraresi et al., 2015). Adding resistance training to aerobic training has resulted in better muscular strength, cardiovascular fitness, mobility, functional status, and VO_{2peak} (Fisher et al., 2013; Marzolini et al., 2018; Villareal et al., 2017; Zambom-Ferraresi et al., 2015). Moreover, participation in resistance training has been associated with reduced central adiposity and unhealthy gain (Artero et al., 2014), cardiovascular and metabolic diseases (Artero et al., 2011; Benson, Torode, & Fiatarone Singh, 2006; Shaibi et al., 2006), increased skeletal health (Vicente-Rodríguez et al., 2008), and aerobic fitness (Faigenbaum et al., 2009). The literature investigating resistance training supports its implementation into the daily physical activity of the young, adult, and senior populations (Kraemer, Ratamess, & French, 2002). However, it was demonstrated that females generally choose to engage more in solely aerobic exercise with the motive to lose weight (Craft, Carroll, & Lustyk, 2014).

Older females engaged in resistance training can gain various physiological benefits, including muscle strength and blood pressure decrease (Silva et al., 2017), along with an increase in functional capacity and quality of life (Ramírez-Campillo et al., 2014). In young females, this type of training is an effective method to enhance jumping performance (Lesinski, Prieske, & Granacher, 2016), as well as self-efficacy (LeCheminant et al., 2014) and mineral density (Zhao, Zhao, & Xu, 2015).

In conjunction with the physiological benefits of resistance training, there are also various psychological benefits for females who practice resistance training. Among them are better self-esteem, improvements in self-concept, body image, emotional well-being, and reduction in anxiety (Tucker & Maxwell, 1992). Considering the number of benefits linked to resistance training, more females should engage in a resistance training program.

It was shown that older men have a similar ability as younger ones to increase muscle power following a periodized mixed resistance training (Newton et al., 2002). This was confirmed in females after 13 weeks of submaximal training, showing progress at the same rate as younger women (Mata, Oliver, Jagim, & Jones, 2016). This research in males and females confirmed that neural adaptation is the primary goal of resistance training programs in order to increase force and power in women across the age spectrum.

Designing a training program that will show maximum effects and allow a person to achieve the optimal benefits is important. Although resistance training has been shown to improve fitness and health status, there is still a considerable debate regarding the optimal ordering of different modes of exercise within an exercise program. Given the fact that only a few studies exist regarding mixed models in females, there is a need to determine the effects mixed resistance training has on specific outcomes (i.e., isometric force and anthropological characteristics). Moreover, little research exists on the impact of solely resistance training on isometric strength and anthropological characteristics in females. Therefore, the purpose of this study was to determine the effects of mixed resistance training on isometric strength parameters and anthropological characteristics in young adult females.

METHODS

Study Design

Anthropological characteristics measurement and force testing were undertaken at the Provincial Institute for Sport in Novi Sad, Serbia. The aim was to test the effects of a 10-week mixed neuromuscular resistance training intervention on isometric force parameters and anthropological characteristics. Pre-tests and post-tests were conducted on two consecutive days, before and after the 10-week treatment period. Participants from the mixed resistance training (MRT) group performed four weeks of muscular endurance resistance training (ERT) followed by six weeks of traditional resistance training (TRT). The control (CON) group did not exercise or use any training intervention during a period of 10 weeks.

Participants

A total of 52 healthy females (age 22.61 ± 1.86 years; height 167.88 ± 5.61 cm; weight 60.22 ± 8.61 kg) were recruited to participate in the study. The participants were selected based on the following criteria: no prior history of lower limb injuries in the past nine months, and no history of resistance or endurance training. Finally, the participants were randomly divided into either the MRT group (n = 25) or the CON group (n = 27). Age, height, weight and BMI data across participants are presented in Table 1, with no significant differences found between the groups at baseline ($p > 0.05$). Written consent and participant assent were provided before initiating the study in accordance with the Novi Sad University Human Research Ethics Committee guidelines (ethical approval number: 234/2020).

Table 1 Characteristics of the participants

	MRT	CON
Age (years)	23.04 ± 1.98	22.22 ± 1.69
Body Height (cm)	166.13 ± 5.13	169.51 ± 5.64
Body Weight (kg)	58.78 ± 7.78	61.56 ± 9.25
BMI (kg/m^2)	21.29 ± 2.58	21.42 ± 3.03

Note: Data is presented as mean ± SD

Abbreviations: MRT - mixed neuromuscular resistance training group, CON - control group

Testing Procedures – Isometric Force Assessment

The testing was done at the Provincial Institute for Sport in Novi Sad, Serbia, on a dynamometric apparatus, and was performed in accordance with basic measuring protocols. It took place in the morning when the temperature was 18–21°C and the relative humidity was 40–60%. All the participants were tested immediately before the beginning of their training season. Isometric muscle force was measured by a dynamometer, manufactured by the Nikola Tesla Electrical-technical Institute in Belgrade, Serbia. The assessment consisted of 3 phases: resting period, workload period, and recovery period. Each measurement was taken three times, and the best attempt was recorded and saved for subsequent analyses. Five topologically defined tests of isometric muscle force were applied: (a) isometric force of right-hand flexors, (b) isometric force of left-hand flexors; (c) isometric force of upper-body flexors; (d) isometric force of upper-body extensors; and (e) isometric force of knee extensors (both legs). The assessment protocol used in this study has been described by Doder, Babiak, Janjić, & Doder (2012).

Testing Procedures – Anthropological Characteristics Assessment

Height and weight were measured in minimal clothing and barefoot. Height was measured to the nearest 0.1 cm with the use of a stadiometer (SECA Instruments Ltd, Hamburg, Germany). Bodyweight and body fat percentage were determined using an InBody230 (InBody Co. Ltd, Cerritos, CA, USA) with the bioelectrical impedance method. BMI was calculated as follows: BMI= (Weight in kilograms)/(Height in meters)^2. InBody230 is a reliable device in men and women as indicated by high intraclass correlation coefficients for relative values - body fat (≥0.98) and a low standard error of measurement (McLester, Nickerson, Kliszczewicz, & McLester, 2018). Before the measurement, the participants were asked to excrete, refrain from drinking excessive amounts of water, and not change their typical breakfast patterns.

Three skinfolds (thigh, triceps, abdomen) were examined for thickness on the right side of the body. Skinfold measurements were taken with a precision of 0.1 mm using a pre-calibrated Harpenden skinfold caliper (Harpenden, West Sussex, UK) according to procedures described by Eston & Reilly (2009).

Waist circumference (WC) was taken at the level between the lowest rib margin and hips. Hip circumference (HC) was taken at the level of the maximum body width below the waist. Waist and hip circumference was measured twice with a precision of 0.1 cm with a constant tension of non-elastic tape (*Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation*, 2011). Furthermore, the waist-to-hip ratio (WHR) was calculated by dividing the WC with the HC using the same units of measurements for both.

Training Program

Muscular Endurance Resistance Training (ERT)

Before training, the participants underwent 10 repetition maximum (RM) testing to determine individual initial training loads for each exercise. Repetition maximum testing was consistent with recognized guidelines as established by the National Strength and Conditioning Association (Baechle & Earle, 2008). The ERT program consisted of 3 supervised sessions a week over a four-week period. This period presented the process of familiarization with exercise and training routine. Each resistance training session consisted of four sets of 15 repetitions at ~60% of 1RM with 60 seconds of rest between sets and 180 seconds of rest between exercises with the slow cadence of execution. If an individual was able to complete four sets of 15 repetitions after two weeks (6 training sessions), the training weight was increased by 2 to 4% to compensate for any strength gains (Haff & Triplett, 2015; Ratamess & Kraemer, 2004) in the last week of ERT program. During five weeks of ERT, the exercises performed were: squats, lunges, the bench press, leg raises, the hyperextension bench, knee extension, hamstring curl, leg adductions, leg abductions, lat pulldowns, rowing torso, biceps curls, triceps extension, and the butterfly bench. All routines were directly supervised and lasted approximately 50 min, including the warm-up, dynamic neuromuscular stabilization (DNS) basic movements according to the DNS approach (Frank, Kobesova, & Kolar, 2013), basic breathing exercises, and a cool-down period.

Traditional Resistance Training (TRT)

All participants started their training with six weeks of TRT. During the six-week period participants performed TRT which consisted of 3 sets of 8 to 12 repetitions at ~60% 1RM

with 80s breaks between sets. The time between the exercises was extended to about 120s, given the extra time needed to set up the equipment for the subsequent resistance exercise. The repetitions were performed up to the point of momentary concentric failure, i.e. the inability to perform another concentric repetition while maintaining the correct form with the cadence of the repetitions was performed in a controlled manner with a concentric action of about 1s and an eccentric action of about 2s. The TRT protocol consisted of seven exercises per session targeting all major muscle groups of the body. This protocol uses some recommendations for training that include large muscle group exercises before small muscle group exercises; multiple-joint exercises before single-joint exercises or rotation of upper and lower body exercises. The exercises performed were: the bench press, flat barbell, inclined bench press, barbell military press, overhead press, wide grip lateral pulldown, seated cable row, barbell back squat, machine leg press and unilateral machine leg extension, squats (additional weights), lunges (additional weights), bicep curls, triceps extension, and the butterfly bench. These exercises were selected on the basis of their common involvement in strength training type programs (Baechle & Earle, 2008; Coburn & Malek, 2012). An attempt was made to gradually increase the weekly lifted loads to ensure that the test participants trained with as much resistance as possible within the limits of the target repetition range. All exercises were directly supervised by the research team to ensure the correct performance of each exercise. The training session lasted approximately 70 minutes, including the warm-up phase, core DNS movements according to the DNS approach (Frank et al., 2013), accompanied by breathing exercises, and the cool-down phase. All participants trained three times a week with at least one day of rest between sessions. To avoid confusion, the test persons were instructed not to perform any additional anaerobic resistance training or high-intensity anaerobic training during the entire duration of the study.

Statistical Analysis

Descriptive statistics were calculated for age, height and body mass. The distribution of the raw data sets was checked with the Kolmogorov-Smirnov test and showed that all data had a normal distribution. A two-way repeated measures ANOVA was used to determine the effects of programs on strength and anthropological characteristics. In addition, we tested the simple main effect of time to detect changes from before and after the tests in MRT and CON. The effect size (ES) of each variable was tested using Cohen's d within each group and classified as follows: 0.2 was defined as trivial; 0.2-0.6 was defined as small; 0.6-1.2 was defined as moderate; 1.2-2.0 was defined as large; 2.0 was defined as very large, and 4.0 was defined as extremely large (Hopkins, Marshall, Batterham, & Hanin, 2009), and partial eta (η) squared between the groups (0.01 = small effect, 0.06 = medium effect and 0.14 = large effect) (Lakens, 2013). All tests were performed with SPSS, version 22 (SPSS Inc., Chicago, IL, USA) and evaluated at the significance level of $p \leq 0.05$.

RESULTS

When examining the impact of the MRT program on isometric force parameters (Table 2), there was a significant group x time interaction in isometric force of right-hand flexors ($F = 11.608$, $p = 0.001$, Partial $\eta^2 = 0.18$) and isometric force of upper-body flexors ($F = 10.329$, $p = 0.002$, Partial $\eta^2 = 0.17$). Highest effects favoring the MRT group were observed in isometric force of the right-hand flexors effect for time ($p < 0.001$). Significant pre-to post-test changes were noted in the MRT group in isometric force of

knee extensors ($p < 0.05$); however, there was no significant group x time interaction ($F = 0.295$, $p = 0.589$, Partial $\eta^2 = 0.006$). Moreover, the results indicate no interaction in isometric force of the left-hand flexors ($F = 1.431$, $p = 0.237$, Partial $\eta^2 = 0.02$) and isometric force of the upper-body extensors ($F = 12.543$, $p = 0.001$, Partial $\eta^2 = 0.20$).

Table 2 Differences between MRT (n=25) and CON (n=27) in isometric measures from the pre- to post- test

	Group	Pretest	Posttest	ES	% change	A Group-by-Time Interaction Effect
Isometric force of the right-hand flexors	MRT	30.48 ± 6.65	34.76 ± 6.05*	+0.66	+13.1%	F = 11.608; *p* = 0.001; η^2_p: 0.188
	CON	30.29 ± 5.29	30.25 ± 5.29	-0.01	-0.1%	
Isometric force of the left-hand flexors	MRT	29.40 ± 3.93	30.84 ± 5.22	+0.31	+4.7%	F = 1.431; *p = 0.*237; η^2_p: 0.028
	CON	27.70 ± 4.27	27.81 ± 4.27	+0.03	+0.3%	
Isometric force of the upper-body flexors	MRT	41.04 ± 8.71	44.20 ± 7.75*	+0.38	+7.4%	F = 10.329; *p = 0.*002; η^2_p: 0.171
	CON	39.77 ± 8.86	39.70 ± 8.88	-0.01	-0.1%	
Isometric force of the upper-body extensors	MRT	99.48 ± 25.65	101.28 ± 21.34	+0.08	+1.7%	F = 0.295; *p = 0.*589; η^2_p: 0.006
	CON	94.14 ± 26.15	94.11 ± 26.13	0.00	0.0%	
Isometric force of the knee extensors	MRT	141.72 ± 39.03	151.84 ± 33.08*	+0.28	+6.8%	F = 2.984; *p = 0.*090; η^2_p: 0.056
	CON	133.92 ± 34.54	136.25 ± 36.39	+0.06	+1.7%	

Note: Pretest and posttest results are presented as mean ± SD
Abbreviations: MRT - mixed neuromuscular resistance training group, CON - control group, ES - effect size for pre- to post- test changes, F - F-test statistics, p - probability value, η^2_p - partial eta squared, * - significant pre- to post-test changes at $p < 0.05$ (the simple main effect of time)

The results of the anthropological characteristics parameters from the repeated measures ANOVA (Table 3) indicated a significant group (MRT vs. CON) × time (pre to post)

Table 3 Differences between MRT (n=25) and CON (n=27) in body composition parameters measures from the pre- to post- test

	Group	Pretest	Posttest	ES	% change	A Group-by-Time Interaction Effect
Body Weight (kg)	MRT	58.78 ± 7.78	59.08 ± 7.36	+0.03	+0.5%	F = 1.333; *p* = 0.254; η^2_p: 0.001
	CON	61.56 ± 9.25	60.75 ± 10.89	-0.08	-1.3%	
BMI	MRT	21.29 ± 2.58	21.4 ± 2.48	+0.04	+0.5%	F = 1.386; *p* = 0.245; η^2_p: 0.027
	CON	21.41 ± 3.03	21.1 ± 3.55	-0.09	-1.4%	
Body Fat (%)	MRT	20.85 ± 5.65	19.12 ± 5.67*	-0.31	-8.6%	F = 98.160; *p* < 0.001; η^2_p: 0.663
	CON	19.05 ± 4.00	19.49 ± 4.03*	+0.11	+2.2%	
Waist-Hip Ratio	MRT	0.72 ± 0.04	0.69 ± 0.02*	-0.95	-4.2%	F= 12.489; *p* = 0.001; η^2_p: 0.200
	CON	0.73 ± 0.05	0.74 ± 0.06	+0.12	+1.0%	
Triceps Skinfold (mm)	MRT	9.56 ± 2.10	7.096 ± 1.37*	-1.37	-29.6%	F = 40.158; *p* < 0.001; η^2_p: 0.445
	CON	10.34 ± 3.91	10.348 ± 3.88	0.00	0.0%	
Tight Skinfold (mm)	MRT	11.30 ± 2.95	10.90 ± 2.14	-0.15	-3.6%	F = 0.701; *p = 0.406;* η^2_p: 0.013
	CON	12.76 ± 4.79	12.75 ± 4.78	0.00	0.0%	
Abdominal Skinfold (mm)	MRT	12.112 ± 4.03	10.84 ± 3.97*	-0.31	-11.0%	F = 12.543; *p* = 0.001; η^2_p: 0.201
	CON	12.963 ± 6.40	12.95 ± 6.40	0.00	0.0%	

Note: Pretest and posttest results are presented as mean ± SD
Abbreviations: MRT - mixed neuromuscular resistance training group, CON - control group, ES - effect size for pre- to post- test changes, F - F-test statistics, p - probability value, η^2_p - partial eta squared, * - significant pre- to post-test changes at $p < 0.05$ (the simple main effect of time)

interaction for body fat ($F = 98.160$, $p < 0.001$, Partial $\eta^2 = 0.66$, See Table 1), Waist-Hip Ratio ($F = 12.489$, $p < 0.001$, Partial $\eta^2 = 0.20$), and in abdominal skinfold ($F = 12.543$, $p = 0.001$, Partial $\eta^2 = 0.20$). Large effects favoring the MRT group were observed in triceps skinfold (ES = -1.37 % change = -29.6%), compared to no effect in the CON group. The analysis did not show any significant group x time interaction and effect on intervention in body weight ($F = 1.333$, $p = 0.254$, Partial $\eta^2 = 0.001$); body mass index ($F = 1.386$, $p = 0.245$, Partial $\eta^2 = 0.02$) and thigh skinfold ($F = 0.701$, $p = 0.406$, Partial $\eta^2 = 0.01$).

DISCUSSION

The effects of resistant training on strength and anthropological characteristics is well known and documented (Eather, Morgan, & Lubans, 2016; Lasevicius et al., 2018; Paoli, Gentil, Moro, Marcolin, & Bianco, 2017; Velez, Golem, & Arent, 2010). However, there is a lack of information on mixed protocols on performance in untrained healthy females. Our mixed resistance training showed significant effects on anthropological characteristics as well as on upper body strength in young adult females. Ten weeks of MRT reduced body fat, waist-to-hip ratio, abdominal skinfold, and triceps skinfolds compared to the control group that showed the same or higher values for anthropological characteristics from pre to post-testing. Moreover, the isometric force of the right-hand flexors and isometric force of the upper-body flexors improved in the MRT group.

It is well documented that aerobic exercise is a powerful way for weight loss, especially body fat loss (Donnelly et al., 2013; Oda, Miyatake, Sakano, & Saito, 2014). On the contrary, Miller et al. (2018) stated that there is a great amount of research in the past several years that examined the effects of resistance training on weight loss. Resistance training showed to be effective in the improvement of anthropological characteristics in overweight/obese women (Campa et al., 2020). Moreover, Cavalcante et al. (2018) demonstrated a decreased body fat level after a low-volume 12-week resistance training program in overweight/obese older women. However, some studies that included resistance training showed to be ineffective for weight loss (Olson, Dengel, Leon, & Schmitz, 2007; Willis et al., 2012). The discrepancy in the results comes from the fact that anthropological characteristics typically do not change much with resistance training because the reduction in fat mass is accompanied by increases in fat-free mass (Hunter, McCarthy, & Bamman, 2004). In the current study, we did not assess fat mass or fat-free mass. However, our mixed resistance training showed a significant reduction in body fat (8.6%) compared to the control group that showed only a 2.2% reduction. Therefore, it could be speculated that our mixed resistance training-induced changes in body fat % and skinfold measurements due to an increase in metabolism in sedentary young adult females, which was started in a similar study but in overweight/obese adults (Willis et al., 2012). Moreover, some other reports that included resistance training showed that the decreases in fat percentage indicate a decrease in fat mass (Banz et al., 2003; Marx et al., 2001; Pollock et al., 2000). We can also assume that significant differences between the MRT and CON group in skinfold thickness and the percentage of body fat were possibly due to changes in body fat distribution.

Our findings showed that the mixed resistance training program showed considerable improvements in isometric force parameters, especially in the right-hand flexors and upper-body flexors. There were improvements in the MRT group in knee extensors but

without differences compared to the control group. This could be explained by the nonspecific nature of knee extension testing compared to the exercise programs. Most of the exercises in the MRT program were performed with isotonic contractions, while during the testing, the isometric contractions were used to quantify strength. This was confirmed by Weiss et al. (Weiss et al., 2007). Moreover, the increases in lower body strength for the MRT group were less than for the hands and torso, which may be explained by the fact that the training program involved more upper body than lower body exercises. Cannon, Kay, Tarpenning, & Marino (2007) demonstrated significant increases in peak isometric torque in knee and muscle hypertrophy after a 10-week resistance training program in young and elderly women. However, resistance training programs consisted only of knee extensors and knee flexors exercises 3 days per week. Moreover, progressive resistance training alone compared to training, and a healthy diet, showed similar improvements in maximal rate of force development during isometric knee contractions in elderly women (Edholm, Strandberg, & Kadi, 2017). In one large population-based study, handgrip strength and lower limb extension power showed a significant and large decline with age (Aadahl, Beyer, Linneberg, Thuesen, & Jørgensen, 2011). However, only handgrip strength was associated with leisure-time physical activity. Therefore, although lower limb explosive capacity has been associated with reduced ability to perform normal daily activities as well as an increased prevalence for fall injuries (Pijnappels, van der Burg, Reeves, & van Dieën, 2008; Skelton, Greig, Davies, & Young, 1994), it is important to perform different physical activities in order to prevent the decline in upper body strength also. The current study showed that mixed resistance training might be a good option to improve whole-body strength, especially the upper part. Our novel findings expand previous research by indicating that improvements in isometric strength can occur following mixed resistance whole-body training after 10 weeks (3 days per week), which is not specific to the modality of the exercise used for testing.

Although the current research showed significant improvements in isometric strength and anthropological characteristics, we did not assess fat-free mass and muscle mass, which could be considered as the biggest limitation. Moreover, leisure physical activity and nutritional control were not measured in both groups. However, the participants were asked to continue their usual diet and to avoid any other physical activity programs. The strength of this study is the fact that females in the current study improved their upper-body isometric strength and reduced their body fat without additional aerobic sessions while instructed not to change their dietary habits.

CONCLUSION

Mixed resistance training can be an effective training modality to improve isometric strength and to stimulate a decrease in anthropological characteristics in young female adults. Based on the results of the current study, it can, therefore, be advised to recommend a mixed resistance training program consisting of muscular endurance resistance training and traditional resistance training, for the improvement of anthropological characteristics markers and strength in an inactive female population.

REFERENCES

Aadahl, M., Beyer, N., Linneberg, A., Thuesen, B. H., & Jørgensen, T. (2011). Grip strength and lower limb extension power in 19-72-year-old Danish men and women: The Health2006 study. *BMJ Open*, *1*(2), e000192. https://doi.org/10.1136/bmjopen-2011-000192

Artero, E. G., España-Romero, V., Jiménez-Pavón, D., Martinez-Gómez, D., Warnberg, J., Gómez-Martínez, S., … Molnar, D. (2014). Muscular fitness, fatness and inflammatory biomarkers in adolescents. *Pediatric Obesity*, *9*(5), 391–400.

Artero, E. G., Ruiz, J. R., Ortega, F. B., España-Romero, V., Vicente-Rodríguez, G., Molnar, D., … Moreno, L. A. (2011). Muscular and cardiorespiratory fitness are independently associated with metabolic risk in adolescents: the HELENA study. *Pediatric Diabetes*, *12*(8), 704–712.

Baechle, T. R., & Earle, R. W. (2008). *Essentials of strength training and conditioning*. Human kinetics.

Banz, W. J., Maher, M. A., Thompson, W. G., Bassett, D. R., Moore, W., Ashraf, M., … Zemel, M. B. (2003). Effects of resistance versus aerobic training on coronary artery disease risk factors. *Experimental Biology and Medicine*, *228*(4), 434–440. https://doi.org/10.1177/153537020322800414

Bauman, A. E. (2004). Updating the evidence that physical activity is good for health: an epidemiological review 2000–2003. *Journal of Science and Medicine in Sport*, *7*(1), 6–19.

Benson, A. C., Torode, M. E., & Fiatarone Singh, M. A. (2006). Muscular strength and cardiorespiratory fitness is associated with higher insulin sensitivity in children and adolescents. *International Journal of Pediatric Obesity*, *1*(4), 222–231.

Bogataj, Š., Pajek, J., Ponikvar, J. B., Hadžić, V., & Pajek, M. (2020). Kinesiologist-guided functional exercise in addition to intradialytic cycling program in end-stage kidney disease patients: a randomised controlled trial. *Scientific Reports*, *10*(1), 1–10.

Brady, S. R. E., Hussain, S. M., Brown, W. J., Heritier, S., Billah, B., Wang, Y., … Cicuttini, F. M. (2016). *SAT0503 Relationships between Weight, Physical Activity and Back Pain in Young Adult Women*. BMJ Publishing Group Ltd.

Brown, R. D., & Harrison, J. M. (1986). The effects of a strength training program on the strength and self-concept of two female age groups. *Research Quarterly for Exercise and Sport*, *57*(4), 315–320. https://doi.org/10.1080/02701367.1986.10608092

Butts, N., & Price, S. (1994). Effects of a 12-week weight training program on the body composition of women over 30 years of age. *The Journal of Strength & Conditioning*, *8*(4), 265–269.

Campa, F., Latessa, P. M., Greco, G., Mauro, M., Mazzuca, P., Spiga, F., & Toselli, S. (2020). Effects of Different Resistance Training Frequencies on Body Composition, Cardiometabolic Risk Factors, and Handgrip Strength in Overweight and Obese Women: A Randomized Controlled Trial. *Journal of Functional Morphology and Kinesiology Article*, *5*(3), 51. https://doi.org/10.3390/jfmk5030051

Cannon, J., Kay, D., Tarpenning, K. M., & Marino, F. E. (2007). Comparative effects of resistance training on peak isometric torque, muscle hypertrophy, voluntary activation and surface EMG between young and elderly women. *Clinical Physiology and Functional Imaging*, *27*(2), 91–100. https://doi.org/10.1111/j.1475-097X.2007.00719.x

Cavalcante, E. F., Ribeiro, A. S., Do Nascimento, M. A., Silva, A. M., Tomeleri, C. M., Nabuco, H. C. G., … Cyrino, E. S. (2018). Effects of Different Resistance Training Frequencies on Fat in Overweight/Obese Older Women. *International Journal of Sports Medicine*, *39*(7), 527–534. https://doi.org/10.1055/a-0599-6555

Coburn, J., & Malek, M. (2012). *NSCA's Essentials of Personal Training 2nd Edition*. Human Kinetics.

Colcombe, S. J., Erickson, K. I., Scalf, P. E., Kim, J. S., Prakash, R., McAuley, E., … Kramer, A. F. (2006). Aerobic Exercise Training Increases Brain Volume in Aging Humans. *The Journals of Gerontology: Series A*, *61*(11), 1166–1170. https://doi.org/10.1093/gerona/61.11.1166

Craft, B. B., Carroll, H. A., & Lustyk, M. K. B. (2014). Gender Differences in Exercise Habits and Quality of Life Reports: Assessing the Moderating Effects of Reasons for Exercise. *International Journal of Liberal Arts and Social Science*, *2*(5), 65–76.

Deslandes, A., Moraes, H., Ferreira, C., Veiga, H., Silveira, H., Mouta, R., … Laks, J. (2009). Exercise and Mental Health: Many Reasons to Move. *Neuropsychobiology*, *59*(4), 191–198. https://doi.org/10.1159/000223730

Doder, D. V., Babiak, J. J., Janjić, N. J., & Doder, R. Ž. (2012). Isometric force development of some muscle groups in athletes. *Journal of Strength and Conditioning Research*, *26*(1), 293–298. https://doi.org/10.1519/JSC.0b013e31821d5c89

Donnelly, J. E., Honas, J. J., Smith, B. K., Mayo, M. S., Gibson, C. A., Sullivan, D. K., … Washburn, R. A. (2013). Aerobic exercise alone results in clinically significant weight loss for men and women: Midwest exercise trial 2. *Obesity*, *21*(3). https://doi.org/10.1002/oby.20145

Eather, N., Morgan, P. J., & Lubans, D. R. (2016). Improving health-related fitness in adolescents: the CrossFit Teens™ randomised controlled trial. *Journal of Sports Sciences*, *34*(3), 209–223.

Edholm, P., Strandberg, E., & Kadi, F. (2017). Lower limb explosive strength capacity in elderly women: effects of resistance training and healthy diet. *J Appl Physiol*, *123*, 190–196. https://doi.org/10.1152/japplphysiol.00924.2016.-The

Eston, R., & Reilly, T. (Eds.). (2009). *Kinanthropometry and Exercise Physiology Laboratory Manual: Tests, Procedures and Data* (Third Edit). Abingdon: Routledge.

Faigenbaum, A. D., Kraemer, W. J., Blimkie, C. J. R., Jeffreys, I., Micheli, L. J., Nitka, M., & Rowland, T. W. (2009). Youth resistance training: updated position statement paper from the national strength and conditioning association. *The Journal of Strength & Conditioning Research*, *23*, S60–S79.

Fisher, G., McCarthy, J. P., Zuckerman, P. A., Bryan, D. R., Bickel, C. S., & Hunter, G. R. (2013). Frequency of combined resistance and aerobic training in older women. *Journal of Strength and Conditioning Research*, *27*(7), 1868–1876. https://doi.org/10.1519/JSC.0b013e31827367e0

Frank, C., Kobesova, A., & Kolar, P. (2013). Dynamic neuromuscular stabilization & sports rehabilitation. *International Journal of Sports Physical Therapy*, *8*(1), 62–73.

Haff, G., & Triplett, N. (Eds.). (2015). *Essentials of strength training and conditioning* (4th editio). Human kinetics.

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009, January). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, Vol. 41, pp. 3–12. https://doi.org/10.1249/MSS.0b013e31818cb278

Hunter, G. R., McCarthy, J. P., & Bamman, M. M. (2004). Effects of resistance training on older adults. *Sports Medicine*, Vol. 34, pp. 329–348. Sports Med. https://doi.org/10.2165/00007256-200434050-00005

Hurley, B. F., & Roth, S. M. (2000). Strength training in the elderly: Effects on risk factors for age-related diseases. *Sports Medicine*, Vol. 30, pp. 249–268. Adis International Ltd. https://doi.org/10.2165/00007256-200030040-00002

Hyde, A. L., Conroy, D. E., Pincus, A. L., & Ram, N. (2011). Unpacking the feel-good effect of free-time physical activity: Between-and within-person associations with pleasant–activated feeling states. *Journal of Sport and Exercise Psychology*, *33*(6), 884–902.

Kraemer, W. J., Ratamess, N. A., & French, D. N. (2002). Resistance training for health and performance. *Current Sports Medicine Reports*, *1*(3), 165–171. https://doi.org/10.1249/00149619-200206000-00007

Kramer, A. F., & Erickson, K. I. (2007). Effects of physical activity on cognition, well-being, and brain: Human interventions. *Alzheimer's and Dementia*, *3*(2 SUPPL.). https://doi.org/10.1016/j.jalz.2007.01.008

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, *4*(NOV), 863. https://doi.org/10.3389/fpsyg.2013.00863

Lasevicius, T., Ugrinowitsch, C., Schoenfeld, B. J., Roschel, H., Tavares, L. D., De Souza, E. O., … Tricoli, V. (2018). Effects of different intensities of resistance training with equated volume load on muscle strength and hypertrophy. *European Journal of Sport Science*, *18*(6), 772–780.

LeCheminant, J. D., Hinman, T., Pratt, K. B., Earl, N., Bailey, B. W., Thackeray, R., & Tucker, L. A. (2014). Effect of resistance training on body composition, self-efficacy, depression, and activity in postpartum women. *Scandinavian Journal of Medicine & Science in Sports*, *24*(2), 414–421.

Lesinski, M., Prieske, O., & Granacher, U. (2016). Effects and dose–response relationships of resistance training on physical performance in youth athletes: a systematic review and meta-analysis. *British Journal of Sports Medicine*, *50*(13), 781–795.

Marx, J. O., Ratamess, N. A., Nindl, B. C., Gotshalk, L. A., Volek, J. S., Dohi, K., … Kraemer, W. J. (2001). Low-volume circuit versus high-volume periodized resistance training in women. *Medicine and Science in Sports and Exercise*, *33*(4), 635–643. https://doi.org/10.1097/00005768-200104000-00019

Marzolini, S., Brooks, D., Oh, P., Jagroop, D., MacIntosh, B. J., Anderson, N. D., … Corbett, D. (2018). Aerobic With Resistance Training or Aerobic Training Alone Poststroke: A Secondary Analysis From a Randomized Clinical Trial. *Neurorehabilitation and Neural Repair*, *32*(3), 209–222. https://doi.org/10.1177/1545968318765692

Mata, J. D., Oliver, J. M., Jagim, A. R., & Jones, M. T. (2016). Sex Differences in Strength and Power Support the Use of a Mixed-Model Approach to Resistance Training Programing. *Strength and Conditioning Journal*, *38*(2), 2–7. https://doi.org/10.1519/SSC.0000000000000182

McLester, C. N., Nickerson, B. S., Kliszczewicz, B. M., & McLester, J. R. (2018). Reliability and Agreement of Various InBody Body Composition Analyzers as Compared to Dual-Energy X-Ray Absorptiometry in Healthy Men and Women. *Journal of Clinical Densitometry*. https://doi.org/10.1016/j.jocd.2018.10.008

Miller, T., Mull, S., Aragon, A. A., Krieger, J., & Schoenfeld, B. J. (2018). Resistance training combined with diet decreases body fat while preserving lean mass independent of resting metabolic rate: A randomized trial. *International Journal of Sport Nutrition and Exercise Metabolism*, *28*(1), 46–54. https://doi.org/10.1123/ijsnem.2017-0221

Newton, R. U., Ha¨kkinen, K., Ha¨kkinen, H., Ha¨kkinen, A., Mccormick, M., Volek, J., & Kraemer, W. J. (2002). Mixed-methods resistance training increases power and strength of young and older men. In *Med. Sci. Sports Exerc* (Vol. 34).

Nichols, D. L., Sanborn, C. F., & Love, A. M. (2001). Resistance training and bone mineral density in adolescent females. *Journal of Pediatrics*, *139*(4), 494–500. https://doi.org/10.1067/mpd.2001.116698

Oda, K., Miyatake, N., Sakano, N., & Saito, T. (2014). Relationship between peak oxygen uptake and regional body composition in Japanese subjects. *Journal of Sport and Health Science*, *3*(3), 233–238.

Olson, T. P., Dengel, D. R., Leon, A. S., & Schmitz, K. H. (2007). Changes in inflammatory biomarkers following one-year of moderate resistance training in overweight women. *International Journal of Obesity*, *31*(6), 996–1003. https://doi.org/10.1038/sj.ijo.0803534

Orcy, R. B., Dias, P. S., Seus, T. L., Barcellos, F. C., & Bohlke, M. (2012). Combined Resistance and Aerobic Exercise is Better than Resistance Training Alone to Improve Functional Performance of Haemodialysis Patients - Results of a Randomized Controlled Trial. *Physiotherapy Research International*, *17*(4), 235–243. https://doi.org/10.1002/pri.1526

Paoli, A., Gentil, P., Moro, T., Marcolin, G., & Bianco, A. (2017). Resistance training with single vs. multi-joint exercises at equal total load volume: effects on body composition, cardiorespiratory fitness, and muscle strength. *Frontiers in Physiology*, *8*, 1105.

Pijnappels, M., van der Burg, (Petra) J. C. E., Reeves, N. D., & van Dieën, J. H. (2008). Identification of elderly fallers by muscle strength measures. *European Journal of Applied Physiology*, *102*(5), 585–592. https://doi.org/10.1007/s00421-007-0613-6

Pollock, M. L., Franklin, B. A., Balady, G. J., Chaitman, B. L., Fleg, J. L., Fletcher, B., … Bazzarre, T. (2000). Resistance Exercise in Individuals With and Without Cardiovascular Disease. *Circulation*, *101*(7), 828–833. https://doi.org/10.1161/01.CIR.101.7.828

Prabhakaran, B., Dowling, E. A., Branch, J. D., Swain, D. P., & Leutholtz, B. C. (1999). Effect of 14 weeks of resistance training on lipid profile and body fat percentage in premenopausal women. *British Journal of Sports Medicine*, *33*(3), 190–195. https://doi.org/10.1136/bjsm.33.3.190

Ramírez-Campillo, R., Castillo, A., Carlos, I., Campos-Jara, C., Andrade, D. C., Álvarez, C., … Marques, M. C. (2014). High-speed resistance training is more effective than low-speed resistance training to increase functional capacity and muscle performance in older women. *Experimental Gerontology*, *58*, 51–57.

Ratamess, N. A., & Kraemer, W. J. (2004). Fundamentals of Resistance Training: Progression and Exercise Prescription. *Medicine & Science in Sports & Exercise*, *36*(4), 674–688. https://doi.org/10.1249/01.MSS.0000121945.36635.61

Shaibi, G. Q., Cruz, M. L., Ball, G. D. C., Weigensberg, M. J., Salem, G. J., Crespo, N. C., & Goran, M. I. (2006). Effects of resistance training on insulin sensitivity in overweight Latino adolescent males. *Medicine and Science in Sports and Exercise*, *38*(7), 1208.

Silva, R. G. da, Silva, D. R. P. da, Pina, F. L. C., Nascimento, M. A. do, Ribeiro, A. S., & Cyrino, E. S. (2017). Effect of two different weekly resistance training frequencies on muscle strength and blood pressure in normotensive older women. *Revista Brasileira de Cineantropometria & Desempenho Humano*, *19*, 118–127.

Skelton, D. A., Greig, C. A., Davies, J. M., & Young, A. (1994). Strength, Power and Related Functional Ability of Healthy People Aged 65-89 Years. In *Age and Ageing* (Vol. 23).

Tucker, L. A., & Maxwell, K. (1992). Effects of weight training on the emotional well-being and body image of females: Predictors of greatest benefit. *American Journal of Health Promotion*, *6*(5), 338–344. https://doi.org/10.4278/0890-1171-6.5.338

Velez, A., Golem, D. L., & Arent, S. M. (2010). The impact of a 12-week resistance training program on strength, body composition, and self-concept of Hispanic adolescents. *The Journal of Strength & Conditioning Research*, *24*(4), 1065–1073.

Vicente-Rodríguez, G., Urzanqui, A., Mesana, M. I., Ortega, F. B., Ruiz, J. R., Ezquerra, J., … Gonzalez-Gross, M. (2008). Physical fitness effect on bone mass is mediated by the independent association between lean mass and bone mass through adolescence: a cross-sectional study. *Journal of Bone and Mineral Metabolism*, *26*(3), 288–294.

Villareal, D. T., Aguirre, L., Gurney, A. B., Waters, D. L., Sinacore, D. R., Colombo, E., … Qualls, C. (2017). Aerobic or resistance exercise, or both, in dieting obese older adults. *New England Journal of Medicine*, *376*(20), 1943–1955. https://doi.org/10.1056/NEJMoa1616338

Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation. (2011). Geneva.

Weiss, E. P., Racette, S. B., Villareal, D. T., Fontana, L., Steger-May, K., Schechtman, K. B., … Holloszy, J. O. (2007). Lower extremity muscle size and strength and aerobic capacity decrease with caloric restriction but not with exercise-induced weight loss. *Journal of Applied Physiology*, *102*(2), 634–640. https://doi.org/10.1152/japplphysiol.00853.2006

Willis, L. H., Slentz, C. A., Bateman, L. A., Shields, A. T., Piner, L. W., Bales, C. W., … Kraus, W. E. (2012). Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults. *Journal of Applied Physiology*, *113*(12), 1831–1837. https://doi.org/10.1152/japplphysiol.01370.2011

Wilson, J. M., Marin, P. J., Rhea, M. R., Wilson, S. M. C., Loenneke, J. P., & Anderson, J. C. (2012). Concurrent Training. *Journal of Strength and Conditioning Research*, *26*(8), 2293–2307. https://doi.org/10.1519/JSC.0b013e31823a3e2d

Zambom-Ferraresi, F., Cebollero, P., Gorostiaga, E. M., Hernández, M., Hueto, J., Cascante, J., … Anton, M. M. (2015). Effects of combined resistance and endurance training versus resistance training alone on strength, exercise capacity, and quality of life in patients with COPD. *Journal of Cardiopulmonary Rehabilitation and Prevention*, *35*(6), 446–453. https://doi.org/10.1097/HCR.0000000000000132

Zhao, R., Zhao, M., & Xu, Z. (2015). The effects of differing resistance training modes on the preservation of bone mineral density in postmenopausal women: a meta-analysis. *Osteoporosis International*, *26*(5), 1605–1618.

KOMBINOVANI TRENING SNAGE POBOLJŠAVA SNAGU I ANTROPOLOŠKE KARAKTERISTIKE MLAĐIH ODRASLIH ŽENA

Ova studija je imala za cilj da ispita efekte desetonedeljnog kombinovanog treninga snage na parametre izometrijske sile i antropoloških karakteristika kod mlađih odraslih žena. Ukupno je 52 ispitanice (22.61 ± 1.86 godina) nasumično podeljeno na kombinovan trening snage (MRT; n = 25) i kontrolnu grupu (CON; n = 27). Parametri antropoloških karakteristika bili su telesna masa, procenat telesnih masti, kožni nabori (triceps, butina, abdomen), dok su parametri snage bili izometrijska sila fleksora šake, fleksori i ekstenzori gornjeg dela tela, kao i ekstenzori oba kolena. MRT grupa je realizovala kombinovan trening snage koji se sastojao od 4 nedelja treninga mišićne izdržljivosti (ERT), uz dodatnih 6 nedelja tradicionalnog treninga sa otporom (TRT), tri puta nedeljno. Što se tiče CON grupe, ona nije učestvovala u organizovanom treningu sa opterećenjem. Dvofaktorska ANOVA ponovljenog merenja je primenjena za određivanje efekata programa na snagu i telesnu kompoziciju. Značajna interakcija grupa x vreme je identifikovana kod varijabli procenta masti ($p < 0.001$), obim struka i kuka ($p = 0.001$), kožni nabor triceps ($p < 0.001$), kožni nabor abdomena ($p = 0.001$), izometrijske sile fleksora desne šake ($p = 0.001$) i izometrijske sile fleksora gornjeg dela tela ($p = 0.002$). Nije pronađena interakcija kod varijabli telesne težine, kožnog nabora butine, izometrijske sile fleksora leve šake, izometrijske sile ekstenzora gornjeg dela tela i izometrijske sile ekstenzora kolena. Trening kombinovanog treninga snage je validna metoda treninga za poboljšanje antropoloških karakteristika, ali njena uloga u izometrijskoj sili nije u potpunosti potvrđena kod mlađih odraslih žena.

Ključne reči: *trening snage, telesna težina, sila, žene*

FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 20, No 1, 2022, pp. 13 - 24
https://doi.org/10.22190/FUPES200305002K

Narrative review article

THE INFLUENCE OF EXTERNAL AND INTERNAL FACTORS ON THE DROP JUMP HEIGHT

UDC 796/799
796.42.012

Dragan Klisarić

Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia

Abstract. *The Drop jump (DJ) is an important tool in muscle power development. There are different factors that determine DJ performance, of which the key external and internal are defined. The aim of this narrative review article is to present the factors that determine the performance of the DJ. The comparative analytical method is used to compare and comment on the results of available scientific studies. The results show that technique and instruction together, among external factors, highly determine DJ height. The highest determination of DJ height has age among its internal factors. These findings contribute to better management of motor abilities testing and the training process in order to accomplish high sports success.*

Key words: *Jump Height, Effects, Instruction, Age*

INTRODUCTION

Athlete training is a complex process from which coaches and athletes strive to achieve the best results. Towards that goal, coaches and athletes invest a lot of will, effort, knowledge, etc., qualities to devise and implement appropriate methods and tools (exercises) that provide adequate stimulus for further development of the athlete's abilities. Plyometrics is the most common and effective method for the development of explosive strength, whose main tool are jumps. According to Bubanj and associates (2010), explosive strength enables an athlete to perform a maximum acceleration of his body. Athletes use a drop jump (DJ) in sports training to develop their abilities, test their current abilities, and rehabilitate themselves. In training, the DJ is mainly used to develop strength and increase jump height (Bobbert, 1990; Marković, 2007; Marković & Mikulić 2010). Many different factors determine the performance of a DJ.

Received March 05, 2020 / Accepted December 31, 2020
Corresponding author: Dragan Klisarić
Faculty of Sport and Physical Education, University of Belgrade, Blagoja Parovića 156, 11000 Belgrade, Serbia
Phone: + 381 11 3531000 • E-mail: dklisaric94@gmail.com

The basic research problem in this article is complex and reads as follows: Which factors determine DJ height, which ones have the highest determination, and does integrated determination exist? The subject of this paper is the factors that determine the performance of the DJ. The basic method in the preparation of this article is a comparative analysis of the results of scientific and professional research. The goal of this paper is to interpret and clarify the factors that determine the DJ, to investigate which factors have the highest determination, and determine whether integrated determination exists.

Jumping and other natural forms of movement are an integral part of many sports and are based on plyometric muscle action. Plyometrics include a stretch-shortening cycle (SSC), consisting of an eccentric, isometric (amortization), and concentric phase. According to Schmidtbleicher (1992), a fast SSC that lasts less than 250 ms and a slow SSC that lasts longer than 250 ms can be distinguished. The characteristic of plyometric exercises is that they are applied with minimal additional load or even without additional load (body weight only). When performing a DJ, different drop heights can be used to dose the intensity of this exercise. According to Zatsiorsky and Kraemer (2006), if the jump is performed from a moderate drop height, this will allow the muscles to generate sufficient force to create an eccentric contraction that activates the muscle spindle (a stretch reflex) that will intensify the subsequent, concentric contraction. Otherwise, if a DJ is performed from an exaggerated drop height, rapid tendon stretching can occur, which Golgi's tendon organ registers and inhibits muscle activation, thereby instantly switching off the concentric contraction. Depending on the duration of the plyometric training program, Stojanović, Ristić, McMaster, & Milanović (2017) found that 12 weeks resulted in a significant improvement in DJ height compared to the 6-week program duration for athletes of different training experience. Veličković, Bojić, & Berić (2017) also confirmed these findings in their study, where a 12-week plyometric training program leads to an improvement in DJ height by 4.83 cm in volleyball players between the ages of 14 and 16.

Factors can be observed as independent variables, which mean that they do not depend on other variables. That being said, they can determine the magnitude and quality of other, dependent variables. A single determination of factors can be called mono-causality, and integrated determination can be called multi-causality. The intensity of the determination of the factor can have different levels, ranging from small, moderate, large to strict determinism (e.g., genes as carriers of hereditary traits). Furthermore, they can determine the independent variable in a negative or positive direction. In integrated determination, a single factor may exhibit a different intensity of determination on the same dependent variable, in accordance with more determining factors, such as poor road conditions combined with the presence of fog, rain, snow, ice, etc.

The division of factors into external and internal was established by Matić (2016a) and further elaborated for the purpose of this article. That distribution is made toward impersonal (ambiance) and personal (individual) attributes. Jump height, external load, and jump technique as external factors, and training level, sex, and age as internal factors are considered.

The aim of this narrative review article is to present the factors that determine the performance of the DJ.

METHODS

In this article a comparative analytical method is used to compare and comment results of relevant scientific articles. By searching PubMed and Google search engines, the relevant articles to the topic of this paper were selected and processed.

RESULTS AND DISCUSSION

External factors that determine DJ performance

Drop height

In studies and sports training, different drop heights are used to improve jump height and other effects of this exercise. There are several studies that have investigated the drop height. Viitasalo and Bosco (1982) in their study investigated the drop height of 20, 40, 60, 80, and 100 cm on the DJ height among students. No statistically significant differences among the students were found in the achieved jump height between the given drop heights. In a subsequent study, Viitasalo, Salo, & Lahtinen (1998) examined the effects of 40 cm and 80 cm drop heights in physically active students and triple jumpers of a national rank. At both drop heights, the triple jumpers achieved the same jump height of 47 cm, while the students performed a jump of 35 cm for both drop heights. Thus, these two cited studies did not find that there was an influence of the drop height factor on jump height. However, Young, Pryor, & Wilson (1995) indicated different, positive findings. Low determination of this factor exists at a 30, 45, and 60 cm drop height, with the highest jump heights achieved at a 30 cm drop height - the smallest height. This is represented in Table 1.

Table 1 Jump height, contact time and jump height/contact time for all conditions-instructions (Young et al., 1995)

	Jump Height (cm)	
Drop Height (cm)	M	SD
Drop Jump for Height (DJ-H)		
30	40.2	7.7
45	39.8	7.9
60	39.6	7.8
Drop Jump for Contact Time (DJ-t)		
30	12.5	6.5
45	10.3	6.1
60	9.3	6.2
Drop Jump for Height/Contact Time (DJ-H/t)		
30	33.1	5.0
45	32.3	5.6
60	31.3	5.8

Legend: M-The Arithmetic Mean; SD-Standard Deviation.

In Matić (2015), the aim was to determine the methodological aspects of intensity optimization for the DJ. His research included a group of strong students and a group of weak students, based on 1RM test in the half squat. Then, all the students performed a DJ from 12 to 82 cm drop heights. The results show that at drop heights of 42, 50, 62 cm, the

highest jump heights are expressed relative to the smaller or larger drop heights. Stronger participants achieved higher jump heights at higher drop heights than at low drop heights, while the weaker did the opposite. Also, differences in the studied variables were found, such as reaction force of the ground, maximum muscular power, average muscular power, ground contact time, etc., where the group of strong participants expressed better values in relation to the weak group. This indicates that there is a need to determine the best drop height individually for every athlete in order to improve the efficiency of training procedures that will lead to greater jump height. Matić (2015) concludes that a good way to dose the intensity of a DJ is to use the drop height when the intensity is defined by the variables examined. Based on more recent findings by Matić (2018) optimal DJ height (DH_{opt}) should be regulated in accordance with maximal muscle strength which is assessed in multi-joint locomotion.

Based on the aforementioned studies, it can be inferred that drop height (acutely) has a low determination of DJ height improvement. In addition, this factor exerts an influence on jump height also through delayed training effects, as evidenced in a study by Gehri, Ricard, Kleiner, & Kirkendall (1998) in which an improvement of 2.79 cm resulted after 12 weeks of DJ training, and in a study by Young, Wilson, & Byrne (1999) where after six weeks of application of this exercise with instructions (DJ-H) and (DJ-H/t), an improvement of 1.9 cm and 1.3 cm occurred. By comparing Gehri and associates (1998) and Young and associates (1999), it can be inferred that a higher delayed effect is achieved with longer training regime duration. Also, in the second study, instruction (DJ-H) led to a larger delayed effect over the same time period, which was specifically explained in the instruction factor. Thus, the drop height factor has low determination of DJ height, whether acting alone or combined with other factors such as instruction, training level, external load, etc.

External load

The applied external load can take the form of free weights, load vests, elastic bands, etc. In their research, scientists have assumed that elastic bands can prompt a SSC, which would contribute to an increase in jump height. Accordingly, two studies are presented explaining the impact of elastic bands on DJ height.

In the first study by Makaruk and associates (2014), the aim was to investigate the influence of supported and standard DJ on exercises involving a rapid SSC. Students who competed in different sports were randomly divided into three groups: a group that performed the assisted DJ; a group that performed the standard DJ; a control group, which did not engage. The assisted jump was performed with a gray, strong elastic band, which was attached to the ceiling, and waistband worn by the examinees. The band was stretched at a distance of 3.5 m and aided 10% of the participant's body mass in the concentric jump phase, but also reduced the load in the eccentric jump phase. All three groups were involved in a 5-week training program using 30 cm and 60 cm drop heights. Prior to the start of the program, a strength test of 1RM was performed in the squat exercise for all three groups, where the group performing the standard DJ and lifted the heaviest weight. Also, all three groups performed a jump from a 30 cm drop height, and the following jump heights were obtained: 37.9 cm for the first group; 39.1 cm for the second group; 37.5 cm for the third group. After five weeks of the training program, the tests were performed again at the same drop height and the following jump heights were obtained: 41.1 cm for the first group; 42.6 cm for the second group; 37.8 cm for the third group. The first two groups enhanced the jump height noticeably compared to the heights before the training program and higher

jump heights compared to the control group. The highest jump height was achieved in the second group.

Testing the groups before the start of the training program at a 60 cm drop height gave the following jump height: 39.6 cm for the first group; 41 cm for the second group; 38.4 cm for the third group. After five weeks of the training program, the tests were performed again at the same drop height and the following jump heights were obtained: 43 cm for the first group; 43.5 cm for the second group; 38.2 cm for the third group. As with the 30 cm drop height, there is a significant improvement in height of the jump compared to the achieved heights before the start of the program and the higher height of the jump in regard to the control group. The highest jump height was achieved in the second group.

Observing the results of the study, both experimental groups tested at 30 cm and 60 cm drop heights significantly improved their jump height compared to the achieved heights prior to the training activity and in regard to the control group.

According to researchers, DJ with elastic load and DJ without load equally influence the height increase over a given period of time. In addition, higher values of the reactive coefficient were found and a significantly lower ground reaction force during the jump with applied elastic loading. Also, elastic bands have contributed to the reduction of impact forces at ground contact, which reduces the risk of injury. It is concluded that the use of elastic bands has significant additional effects, so it can be used to improve jump height in sports such as basketball, volleyball, athletics, etc.

In another study by Aboodarda and associates (2014), the goal was to investigate the impact of elastic bands in the DJ eccentric part in one session. All of the athletes participating in the study were able to lift weight in the squat twice as much as their body mass. They made the DJ in three ways: no additional load; 20% load of body mass from elastic bands; 30% load of body mass from elastic bands. Gray, black, blue, red, yellow colors of elastic bands were used in combination to achieve the desired load. The jump was performed with the assistants standing with their feet fixed on one end of the elastic bands, while the other end of the bands was attached to the examinee. Elastic bands provided an eccentric load during the drop phase, and then assistants released one end of the band during the amortization phase to perform the concentric phase without additional loading. DJ was performed with a drop height of 20, 35, and 50 cm. Test results show that each group achieved almost identical jump heights at all jump heights, ranging from 39 cm to 41 cm. When DJ was performed with an elastic load at a drop height of 35 cm, greater jump heights of 1 cm were achieved than for the DJ without a load. This indicates that the elastic load in the form of elastic bands has a small influence on the acute increase in DJ at the determined drop height. Also, the application of this load increases the tolerance of athletes to a large eccentric load during the amortization phase, which may have significance in reducing injuries. This can be especially useful for sports with a high eccentric load, such as athletics, gymnastics, and alpine skiing.

Analyzing the described studies, the external load in the form of elastic bands can act acutely and in a delayed fashion. With acute action, it has a small influence on increasing the height of the DJ, while delayed action for 5 weeks affects the similar increase in the height of the DJ and the jump without any additional load. In the first study, this factor acts contingently with the drop height factor, and a higher jump height is obtained at a 30 cm drop height than at a 60 cm drop height. In the second study, a contingent effect manifested at a 35 cm jump height. It can be concluded that elastic bands have a small effect of increasing the height of the DJ and have additional described effects, and their use in previously mentioned sports is recommended. For more practical jump performance, it is recommended to wear belts that allow the elastic bands to be released quickly.

Jump technique

A DJ is a jump that is performed from a standing position from a platform of a certain height by moving one-foot forward – the initial position (a), then dropping on both feet simultaneously – the amortization phase (b) and performing a maximal jump (c).

When performing a DJ, it is not recommended to jump out from the box, because it can lead to a longer amortization phase and produce high impact forces on the ground. Depending on the goal, a variety of DJ techniques can be applied, such as: performing a jump on two legs, on one leg, with a longer or shorter amortization phase, as explained in a subsequent study.

Depending on the duration of the amortization phase, Bobbert and Huijing (1987) divided the jumps into two groups:

- The Amortization drop jump (ADJ) characterized by larger downward movement and longer amortization phase. It corresponds to a long SSC;
- The Reactive drop jump (RDJ) characterized by smaller downward movement and shorter amortization phase. It corresponds to a short SSC.

Based on the results of a study by Bobbert and Huijing (1987), in which participants performed a DJ of 20, 40, and 60 cm, it was found that the body's center of gravity is higher when performing a DJ of 20 and 40 cm, compared to a drop from 60 cm. The first performance corresponds to the RDJ technique, while the second corresponds to the ADJ technique. The use of the ADJ technique resulted in a higher jump than the RDJ technique. The authors do not see the purpose of making RDJ from a 60 cm drop height, so they recommend using a 20 to 40 cm drop height for this technique.

Basketball is a sport that requires the exertion of explosive movements in order to achieve maximum jump height or to perform rapid changes of direction, acceleration, stopping, etc. In a study by Struzik, Juras, Pietraszewski, & Rokita (2016), differences between ADJ and RDJ techniques were studied in a group of young basketball players at 15, 30, 45, and 60 cm drop heights. When performing both jumps, hands were held on the hips. At given drop heights, fairly consistent jump height values were obtained for the ADJ technique from 0.33 cm to 0.35 cm; and there are also consistent jump heights from 0.28 to 0.30 cm for the RDJ technique. It can be concluded that at the same drop heights, participants with the ADJ technique achieve higher jump heights than with the RDJ technique. Therefore, depending on the given situation or the purpose of the training, the technique of the DJ should be adapted to produce the desired adaptations in basketball or another sport.

Analyzing the described studies, the jump technique highly determines the magnitude of DJ height. Also, in the case of integrated action with the drop height, the determination of the DJ is increased.

Instruction

When performing some movement or locomotion, the verbal instructions given by the coaches and researchers to the athletes can significantly affect the quality of the performance. There are verbal instructions with an external focus that direct the attention of the person to the environment, and instructions with an internal focus that direct attention to the movements and locomotion of the person. External focus instruction has been shown to have a far greater effect than internal focus instruction.

In a study by Young and associates (1995), which aimed to compare the act of separate instructions on DJ and countermovement jump (CMJ) performance, 17 students with experience in sports and jumping participated. The participants performed a DJ from 30, 45, and 60 cm, where three conditions (instructions) were made:

- Perform a DJ in order to achieve maximal jump height (DJ-H); participants strive to achieve maximum jump height,
- Perform a DJ in order to achieve maximal jump height and immediate contact with the floor (DJ-H/t); participants strive to achieve a maximum height of the jump, and reduce the time of contact with the floor,
- Perform a DJ in order to achieve a short contact time (DJ-t); participants strive to achieve minimum ground contact time.

Analyzing the results of the study, it can be concluded that the greatest DJ heights are achieved with (DJ-H) instruction compared to other instructions; the (DJ-H) instruction corresponds to the ADJ jump execution technique. Therefore, in improving the jumps and making specific adaptations in the training process, instructions should be used to make the athletes perform jumps similar to those performed in competitive conditions. That is, if the sport requires explosive strength, it is recommended to use a (DJ-H) instruction, which will allow a maximum jump height. However, in the case of a sport requiring the use of reactive power, (DJ-H/t) instruction is recommended, which will allow the power to be displayed in the shortest possible time.

In a more recent study by Oliver, Barillas, Lloyd, Moore, & Pedley (2019) which examined the effect of verbal instruction with an external focus on young football players on performing DJ from 30 cm drop height, there were four different performance conditions:

- Control conditions (CONT): "With your hands on your hips, step off with one leg, drop on both feet, and perform a maximal jump";
- Contact instruction (CI): "Make contact with the ground as short as possible";
- Height instruction (HI): "Get as close to the ceiling as possible";
- Quiet Performance instruction (QPI): "During the performance, try to make the quiet drop, then perform a maximal jump."

Analyzing the study results, all the instructions produced a specific immediate response. On average, the (HC) instruction determined a higher jump height in regard to other instructions, which can be seen in Table 2.

Table 2 Average drop jump heights for all performance conditions

Performance measures	CONT	CI	HI	QPI
Jump height (cm)	23.5	21.4	26.0	21.9

Legend: CONT-Control Conditions; CI-Contact Instruction; HI-Height Instruction; QPI-Quiet Performance Instruction.

In order to develop the reactive power of young athletes, a CI should be introduced gradually to minimize the risk of injury. The findings of the study by Oliver and associates (2019) are in line with previously conducted studies that examined instructions with an external focus in adults and found that performing a DJ depends on the conditions of the instruction given (McNair, Prapavessis, & Callender, 2000; Prapavessis, McNair, Anderson, & Hohepa, 2003; Khuu, Musalem, & Beach, 2015).

Comparing the studies, an integrated act of the instruction (DJ-H) and technique in the first study has a high determination on the expression of a higher jump height than the other

instructions. In the second study HI: "Get as close to the ceiling as possible" had a small influence on achieving greater jump height. Depending on the goal of performing the movement and locomotion, whether it is a research or training process, coaches and other professionals should use appropriate instruction to increase DJ height and improve the quality of the performance.

Internal factors that determine DJ performance

Training level

Training level implies varying degrees of motor abilities, which one possesses. Muscle force (strength) is one of the key motor abilities, which according to Kukolj (2006) represent the ability of a muscle to act with great forces under static conditions or against high resistance at low speeds of muscle contraction. A study by Matić (2015) found that weaker participants achieved greater DJ height after smaller drop heights (22-32 cm) than from higher drop heights (62, 72, 82 cm), while stronger participants increased DJ height from a higher drop height. This indicates that stronger participants need a greater external load (drop height) in order to exert maximum muscle power during the concentric jump phase and thus achieve greater jump heights. Since this is a higher external load (drop height), it is, therefore, necessary to exert greater muscle force. It can be concluded that the level of training determines which level of the drop height will be applied in the testing or training process.

Beattie and associates (2017) examined the connection between maximal muscle strength and reactive power. Athletes, based on the measured maximal isometric force (strength) in the mid-thigh pull, are divided into a strong and weak group. Then, all the participants performed a DJ from 30, 40, 50, 60 cm. Analyzing the study results, weaker athletes achieved lower jump heights at higher drop heights, while stronger athletes showed the same values at all drop heights. Also, the results show that stronger athletes achieved significantly higher jump heights at all drop heights compared to weaker participants. This indicates the importance of training for the development of muscle strength, which contributes to greater DJ height.

It can be concluded that the training level factor, specifically muscle strength in the first study, acts in combination with the drop height, which determining a higher DJ height. In another study, the combined influence of these factors can only be observed in weaker participants, which is not the case in stronger participants.

Sex

Sex refers to the biological characteristics of men and women. There are some obvious physical differences between men and women. Also, men and women differentiate in upper body size and strength, which can determine and limit success in sports movements, like spike velocity in volleyball or shooting range in basketball (Zatsiorsky, Kreamer, Fry, 2020). This and other differences need to be considered when training athletes.

Laffaye and Choukou (2010) examined the difference in DJ height between nine top male volleyball players and nine top female volleyball players at 30 and 60 cm drop height. From the results, men achieved, on average, higher jump heights of 46.6 cm for the DJ30 and 46.5 cm for the DJ60 than women who achieved 36.3 cm for the DJ30 and 35.7 cm for the DJ60. This can be represented by an average difference of 46.6 cm for men and 36 cm for women, or 22.7% difference between the sexes. Also, it has been observed that the

technique at the DJ60 in both sexes changes with respect to the DJ30, indicating that this height is not adequate. This means that it is needful to find the appropriate drop height for both sexes. Also, coaches should approach with appropriate instruction for both sexes and correct poor jump technique.

In several sports disciplines, unsteady activities such as jumping on rough terrain in football or jumping on a mat in gymnastics occur. In order to meet the specific requirements of sports discipline, Pilates balls, BOSU balls, and balance discs are often used in training. In a study by Prieske and associates (2014), the difference between physically active men and women when performing a DJ from a drop height of 40 cm on a stable and unstable surface was examined. Higher jump heights were found that were performed under stable conditions compared to unstable conditions. Jump height was significantly lower for jumping on unstable ground, and no sex differences were found in jump height.

Analyzing the described studies, it can be noticed that higher jump heights in the first study were accomplished with an integrated determination of training level factor and sex factor, whereas the introduction of unstable substrate factors, as described in the second study, led to a lower result.

Age

Age and maturation highly determine the expression of motor abilities. There is a big difference in DJ heights achieved between children and adults. Lazaridis and associates (2010) investigated the difference between 12 untrained pre-pubertal boys and untrained men in a DJ of 20 cm drop height. The results of the study show that men performed a 33 cm jump height on average, while boys achieved 15 cm. In addition, less electromyographic muscle activity and activation of the stretch reflex were measured in boys compared to men; the worse performance of the boys' technique by more flexion in the hips during the amortization phase, indicating a less efficient use of SSC. Therefore, it was concluded that the height of the DJ is age-dependent.

Snyder and associates (2018) investigated the difference between a group of young basketball players aged 16 and a group of adult men (strength-trained) at the age of 23 in performing a DJ from 40 cm drop height. The results show that men achieved a 36 cm jump height on average, in regard to adolescents, who achieved 30 cm. The instruction was to make the highest and fastest jump.

It can be concluded that in the second study, higher jump heights were achieved by a greater influence of age and training level factors by the integrated act. Regarding the difference of jump heights between the groups, it is observed that in the first study there are twice bigger differences, which is exclusively achieved by the difference in years since both groups are untrained. In the second study, the difference between the groups is much smaller, which can be attributed to the specificity of basketball training that involves plyometric and strength exercises, as well as older age. On the basis of the above, it can be concluded that in the first study the greatest influence on DJ height is realized by the age factor, while in the second study there is an integrated effect of the age and training level factors.

According to Bompa and Buzzichelli (2015), at the age of 11-14 (early adolescence), training for children may contain low-intensity plyometric exercises, which should be applied as a game, while more demanding plyometric exercises should be included when children reach the age of 15 to 18 years (middle adolescence). A condition for good performance of jumps in children and young people is correct technique and sufficient development of muscular strength.

CONCLUSION

In this article, it was determined that all the considered factors determine DJ height. The highest determination in the case of external factors have technique and instruction factors by their combined effect, depending on the type of instruction given, the athlete/participant adapts the technique of the DJ. In this way, shorter or longer contact with the ground is achieved, as well as greater or lesser amplitude in the joints of the hip, knee, feet during the amortization phase of the jump, and that way it contributes to a higher DJ height. The highest determination among internal factors were found for the age factor, where children and adolescents, despite their training level factor, achieve significantly lower jump heights than adult participants. However, if the training factor is considered, whose greater impact can be expected at the age of middle or late adolescence (higher training loads and more specific training) than early adolescence, the difference in jump heights compared to adults will be smaller.

It is important to mention that in addition to the intensity of the influence of factors, there are other important effects of certain factors. Namely, drop height is the main factor that defines the intensity of DJ load, indicating the individual differences of athletes/participants and the need to determine the optimal height for each individual in order to make adequate progress in motor abilities and jump height. Then, elastic bands are a factor that can determine the tolerance threshold of large eccentric loads, thereby producing a specific effect essential for sports such as athletics, gymnastics, alpine skiing, and others. In addition, they also contribute to reducing the impact force of the jump during the amortization phase, and minimizing the risk of injury. Next, the level of training, that is, the muscle force (strength) in the 1RM test and in the isometric test shows a reliable relationship with DJ height, indicating the importance of this motor ability and the application of the aforementioned tests. Then, sex is a factor that indicates the specificity of the sexes and also higher DJ heights achieved in highly trained male volleyball players compared to female volleyball players. There were no differences between the sexes in the recreationally trained participants, but with the introduction of an unstable surface, jump height was significantly smaller for both sexes compared to stable conditions.

Coaches and other sports professionals from athletics, basketball, volleyball, football, handball, and others, should have a holistic knowledge of the determination and other important effects of external and internal factors affecting DJ height in order to manage the training process more effectively and efficiently. Also, it is necessary to further deepen the knowledge of the determination of external and internal factors, as well as other effects of the DJ, using scientific methods and instruments. To more accurately measure the level of determination of these and other factors, it is necessary to prepare an impact scale in advance with defined criteria and values for distribution by levels on a given scale.

REFERENCES

Aboodarda, S.J., Byrne, J.M., Samson, M., Wilson, B.D., Mokhtar, A.H., & Behm, D.G. (2014). Does performing drop jumps with additional eccentric loading improve jump performance? *The Journal of Strength & Conditioning Research, 28*(8), 2314-2323.

Bompa, O.T., & Buzzichelli, C. (2015). *Conditioning young athletes.* USA: Human Kinetics.

Beattie, K., Carson, B. P., Lyons, M., & Kenny, I. C. (2017). The relationship between maximal strength and reactive strength. *International Journal of Sports Physiology and Performance, 12*(4), 548-553.

Bobbert, M.F. (1990). Drop jumping as a training method for jumping ability. *Sports Medicine, 9*(1), 7-22.

Bobbert, M.F., & Huijing, P.A. (1987). Drop jumping. II. The influence of dropping height on the biomechanics of drop jumping. *Medicine and Science in Sports and Exercise*, *19*(4), 339-346.

Bubanj, S., Stanković, R., Bubanj, R., Dimić, A., Bednarik, J., & Kolar, E. (2010). One leg vs two-legs vertical jumping performance. *Facta Universitatis Series Physical Education and Sport*, *8*(1), 89-95.

Gehri, D.J., Ricard, M.D., Kleiner, D.M., & Kirkendall, D.T. (1998). A comparison of plyometric training techniques for improving vertical jump ability and energy production. *Journal of Strength and Conditioning Research*, *12*, 85-89.

Kukolj, M. (2006). *Antropomotorika (Anthropomotorics)*. Faculty of Sport and Physical Education, University of Belgrade. In Serbian

Khuu, S., Musalem, L.L., & Beach, T.A. (2015). Verbal instructions acutely affect drop vertical jump biomechanics-Implications for athletic performance and injury risk assessments. *The Journal of Strength and Conditioning Research*, *29*(10), 2816-2826.

Laffaye, G., & Choukou, M.A. (2010). Sex bias in the effect of dropping height on jumping performance in volleyball players. *The Journal of Strength and Conditioning Research*, *24*(8), 2143-2148.

Lazaridis, S., Bassa, E., Patikas, D., Giakas, G., Gollhofer, A., & Kotzamanidis, C. (2010). Neuromuscular differences between pre-pubescents boys and adult men during drop jump. *European Journal of Applied Physiology*, *110*(1), 67-74.

Matić, M. (2015). Metodološki aspekti optimizacije intenziteta kod skoka iz saskoka (Methodological aspects of intensity optimization in drop jump). Doctoral Dissertation, Belgrade: Faculty of Sport and Physical Education, University of Belgrade. In Serbian

Matić, M. (2016a). Faktori koji utiču na optimalnu visinu skoka iz saskoka (Factors that affect the optimal jump height in drop jump). *Godišnjak*, *21*, 121-134. In Serbian

Marković, G. (2007). Does plyometric training improve vertical jump height? A meta-analytical review. *British Journal of Sports Medicine*, *41*(6), 349-355.

Marković, G., & Mikulić, P. (2010). Neuro-musculoskeletal and performance adaptations to lower-extremity plyometric training. *Sports Medicine*, *40*(10), 859-895.

Makaruk, H., Winchester, J.B., Czaplicki, A., Sacewicz, T., Zieliński, J., & Sadowski, J. (2014). Effects of assisted and traditional drop jumps on jumping performance. *International Journal of Sports Science and Coaching*, *9*(5), 1217-1225.

McNair, P.J., Prapavessis, H., & Callender, K. (2000). Decreasing landing forces: effect of instruction. *British Journal of Sports Medicine*, *34*(4), 293-296.

Oliver, J.L., Barillas, S.R., Lloyd, R.S., Moore, I., & Pedley, J. (2019). External cueing influences drop jump performance in trained young soccer players. *The Journal of Strength and Conditioning Research*, https://doi.org/10.1519/JSC.0000000000002935.

Prapavessis, H., McNair, P. J., Anderson, K., & Hohepa, M. (2003). Decreasing landing forces in children: the effect of instructions. *Journal of Orthopaedic and Sports Physical Therapy*, *33*(4), 204-207.

Prieske, O., Muehlbauer, T., Krüger, T., Kibele, A., Behm, D., & Granacher, U. (2015). Sex-specific effects of surface instability on drop jump and landing biomechanics, *International Journal of Sports Medicine*, *36*(1), 75-81.

Schmidtbleicher, D. (1992). Training for power event. In: P.V. Komi (Ed.), *Strength and power in sport*, (pp. 381-395). London: Blackwell Scientific.

Snyder, B., Munford, S., Connaboy, C., Lamont, H., Davis, S., & Moir, G. (2018). Assessing plyometric ability during vertical jumps performed by adults and adolescents. *Sports*, *6*(4), 132.

Stojanović, E., Ristić, V., McMaster, D. T., & Milanović, Z. (2017). Effect of plyometric training on vertical jump performance in female athletes: a systematic review and meta-analysis. *Sports Medicine*, *47*(5), 975-986.

Struzik, A., Juras, G., Pietraszewski, B., & Rokita, A. (2016). Effect of drop jump technique on the reactive strength index. *Journal of Human Kinetics*, *52*(1), 157-164.

Veličković, M., Bojić, I., & Berić, D. (2018). The effects of programmed training on development of explosive strength in female volleyball players. *Facta Universitatis Series Physical Education and Sport*, *15*(3), 493-499.

Viitasalo, J.T., & Bosco, C. (1982). Electromechanical behaviour of human muscles in vertical jumps. European *Journal of Applied Physiology and Occupational Physiology*, *48*(2), 253-261.

Viitasalo, J.T., Salo, A., & Lahtinen, J. (1998). Neuromuscular functioning of athletes and non-athletes in the drop jump. *European Journal of Applied Physiology and Occupational Physiology*, 78(5), 432-440.

Young, W.B., Pryor, J.F., & Wilson, G.J. (1995). Countermovement and Drop Jump Performance. *Journal of Strength and Conditioning Research*, *9*(4), 232-236.

Young, W.B., Wilson, C.J., & Byrne, C. (1999). A comparison of drop jump training methods: Effects on leg extensor strength qualities and jumping performance. *International Journal of Sports Medicine*, *20*(05), 295-303.

Zatsiorsky, V.M., & Kraemer, W.J. (2006). *Science and practice of strength training*. Human Kinetics.

Zatsiorsky, V.M., Kraemer, W.J., & Fry, A.C. (2020). *Science and practice of strength training*. Human Kinetics.

UTICAJ SPOLJAŠNJIH I UNUTRAŠNJIH ČINILACA NA VISINU SKOKA IZ SASKOKA

Skok iz saskoka (prema engl. Drop Jump, DJ), je važno sredstvo u razvoju snage mišića. Postoje različiti faktori koji određuju DJ, sa definisanim ključnim spoljašnjim i unutrašnjim faktorima. Cilj ovog narativnog preglednog rada je da se predstave faktori koji karakterišu tehniku izvođenja skoka iz saskoka. U radu je korišćena komparativna analitička metoda, kojom su upoređivani i diskutovani rezultati dostupnih naučnih istraživanja. Rezultati istraživanja su pokazali da tehnika i instrukcija zajedno u najvećoj meri određuju visinu DJ kod spoljašnjih faktora. Kod unutrašnjih faktora uzrast najviše određuje visinu DJ. Dobijeni rezultati doprinose kvalitetnijem upravljanju testiranja sposobnosti i trenažnog procesa sa ciljem ostvarivanja visokog sportskog uspeha.

Ključne reči: *visina skoka, efekti, instrukcija, godine života*

FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 20, No 1, 2022, pp. 25 - 34
https://doi.org/10.22190/FUPES201111003B

Research article

EMPOWERING A SUPPORTIVE PHYSICAL EDUCATION LEARNING CULTURE FOR THE DEVELOPMENT OF STUDENTS' SOCIAL SELF-ESTEEM

UDC 796.01:316.7:159.923.5

Jusuf Blegur, Christin P. M. Rajagukguk, Renya Rosari

Universitas Kristen Artha Wacana, Kupang, Indonesia

Abstract. *Physical education is a subject that requires students to perform openly in public. It seems a more critical way because it needs feedback from teachers and classmates. Many students experience a crisis in social self-esteem because of negligence in their performance. This study aims to test the determination of teacher and classmate support for students' social self-esteem. The participants were 94 junior high school students, grade 7 (M = 12.7660; SD = 0.53733). We collected the data using The Teacher and Classmate Support Scale and Social Self-Esteem Inventory. The data were analyzed descriptively and with the t-test. The results of teacher and classmate support and students' social self-esteem variables show positive results, as well as proving that teacher and classmate support affects students' social self-esteem during physical education learning activities. The presence of teachers in the learning class is necessary to provide social, emotional, and cognitive support to students so that they become more confident in performing their abilities and also feel comfortable with every performance they produce in some learning experiences and expressive learning cultures.*

Key words: *Physical education culture, teacher support, classmate support, social self-esteem*

1. INTRODUCTION

The learning process is an action taken by teachers and students to achieve goals. In this sense, learning is a process that helps students to be more optimal in using their reasoning, psycho-social abilities and skills. Learning activities should help students to recognize and explore their potential and competencies through various approaches, models, methods, and learning strategies (Blegur, Mae, & Souisa, 2018). It has to be the

Received November 11, 2020 / Accepted December 17, 2021
Corresponding author: Jusuf Blegur
Universitas Kristen Artha Wacana, Kupang, Indonesia
E-mail: jusufblegur@ukaw.ac.id

reason for the teacher to carry out learning to help students strive and change to be more constructive and productive during and after completing the learning process. Also, the teacher is responsible for formulating student subject matter, selective in determining learning methods and strategies, dynamic in organizing classroom learning, as well as being a humanist and supportive when providing feedback and evaluating student performance and the learning outcomes. Teachers need to pay attention to all these segments in a holistic and balanced manner so that students learn in an atmosphere that is motivational, active, participatory, expressive, and joyful because such learning behavior is the initial capital for students to succeed in learning.

One of the most important human traits for achieving goals is self-esteem (Doodman, Zadeh, & Changizi, 2017), because self-esteem is related to performance (Nyarko, 2017), and student success (Duraku & Hoxha, 2018). So in communicating and interacting, the teacher needs to protect the human rights that students have by not applying punishment during the disciplinary process and so on. Physical and social punishment that teachers implement will only increase aggression, antisocial behavior, low relationship quality, depression, and lack of moral internalization of students (Smith, 2006). Teachers should appreciate students' effort and offer various solutions if students do not complete their tasks, not punish and intimidate students with verbal and physical violence that makes them feel unworthy in front of others. Whether the teacher is aware or not, every social interaction is related to student self-esteem (Widodo & Pratitis, 2013). When teachers respond to students' work with negative feedback or verbal abuse, it will break the development of the self-esteem, emotional well-being, and physical condition of students (Noh & Talaat, 2012). The reason is that this feedback is a form of “legitimization” that students are not better than their classmates. When teachers or classmates bully each other, there is an invasion of privacy that can damage the psycho-social development of students in learning; even its culmination can trigger tension among fellow students.

Besides the parents, teachers and classmates are also the main models for developing student self-esteem with verbal and non-verbal feedback that is friendly, supportive, and constructive. At the same time, teachers and classmates can also undermine students’ self-esteem with sarcastic, destructive, and intimidating feedback (Mackowicz, 2013). Giving negative feedback in learning activities can damage the development of student self-esteem (Ickes, Wicklund, & Ferris, 1973). Self-esteem contributes positively to one’s moral intelligence (Mulkam, 2016). If students have negative self-esteem, they will also have negative moral intelligence. For instance, students are not prepared to receive negative feedback (Brockner, Derr, & Laing, 1987), to respond to destructive failure (Shrauger & Rosenberg, 1970), they have low assertiveness (Ginting & Masykur, 2014), are easily exposed to negative pressure from the environment (Hidayat, 2013), suffer from high emotional distress (Brown, 2009) and projected levels of depression (Orth, Robins, & Roberts, 2008; Aditomo & Retnowati, 2014; Manna, Falgares, Ingoglia, Como, & Santis, 2016; Babore, Trumello, Candelori, Paciello, & Cerniglia, 2016).

Social support from parents, teachers, and classmates are important for students' psycho-social and academic development. Previous studies have proved by providing information about the importance of teacher support for student life satisfaction (Guess & McCane-Bowling, 2013), student learning achievement (Yu & Singh, 2016; Sharma, 2016), as well as students' academic emotions (Lei, Cui, & Chiu, 2018). The results of the study by Lei et al. also strengthen the strong correlation between teacher support and student academic emotions, in which East Asian students have higher academic emotion

than Western European and American students because East Asian teacher support is more felt by students (Lei, Cui, & Chiu, 2018). Besides social support, there are four counseling strategies offered to improve students' self-esteem, but they are still limited to conceptual ideas. These strategies are to recognize values, stop dangerous thought patterns, start learning new thinking patterns, and be patient (Bruno & Njoku, 2014). In particular, Hein & Caune (2014) conducted a study on the social support of physical education teachers for student self-esteem, where physical self-esteem is present through satisfaction for autonomy and motivational behavior.

Students' emotional symptoms are not only influenced by teacher support but also by classmate support (Demaray, Malecki, Davidson, Hodgson, & Rebus, 2005). If students treat others badly, then they will experience unstable emotional symptoms. For example, teenagers in America give bad ratings to classmates because they get bad treatment from classmates (Pisula & Lukowska, 2011). Other research also shows the importance of relationships between classmates for students' positive adjustment because the social function perceived by classmates is associated with fluctuations in self-esteem (Nelis & Bukowski, 2019); social support from classmates is a significant antecedent variable for student self-esteem. It reduces levels of depression and helps students to be pleased by promoting positive emotions (Bum & Jeon, 2016). Previous studies have not provided empirical evidence of teacher social support for students' social self-esteem in physical education learning activities. For this reason, the research confirms the direction of the teacher social support study (such as treating students fairly and being kind and friendly to students and others) and classmate support toward student self-esteem during physical education learning.

2. Material and Methods

2.1. Participants

The participants involved were 94 students, grade 7, 42 males (44.7%) and 52 females (55.3%) (M = 12.7660; SD = 0.53733). The participants were determined using proportional stratified random sampling using the norms of Krejcie & Morgan (1990) from a population of 185 students. The participants were divided into class A, 15 students, class B, 16 students, class C, 16 students, class D, 16 students, class, E 15 students, and class F, 16 students.

2.2. Measuring instrument

We collected data on teacher and classmate support using The Teacher and Classmate Support Scale (TTCS) created by Torsheim, World, and Samdal in 2000. This scale was developed from 2 main indicators; *teacher support* which has a reliability value of 0.69 and *classmate support* which has a reliability value of 0.74. One statement included in the TTCS is "*Our teachers treat us fairly* and *Most of the students in my class are kind and helpful*." Further, we collected data on the students' social self-esteem using the Social Self-Esteem Inventory of Lawson, Marshall, and McGrath in 1979. Formerly this scale consisted of 30 statement items with a reliability value of 0.88. However, in 2013, the Social Self-Esteem Inventory (SSEI) was simplified and retested by Kerla and Repišti by involving 185 adolescents, with a reliability value of 0.837, and the Guttman split-half value of 0.853. SSEI was modified on a 5-point Likert scale. Some of the statements in

the SSEI are "*I can really make other people feel good in my presence* dan *I am good at holding people's attention and interest*."

2.3. Data analysis

Descriptive analysis is used to profile teacher and classmate support as well as student social self-esteem, while simple linear regression analysis is used to measure the magnitude of the prediction of the variable teacher and peer support on student self-esteem. The t-test (independent sample t-test) was also used to see the difference between indicators of teacher support and indicators of classmate support on students' social self-esteem. All statistical tests were calculated using the SPSS program. If the sig value is less than 0.05, then there is an influence between the teacher and classmate support variables on student self-esteem, and there is a difference between teacher support and classmate support on student self-esteem.

3. RESULTS

3.1. Descriptive analysis

We need to categorize the two research variables, so we use descriptive analysis. Each variable is categorized into five segment: very good, good, fair, poor, and very poor (see table 1).

Table 1 Description analysis

Teacher and classmate support		Category	Social self-esteem	
F	%		F	%
53	56.38	Very good	34	36.17
31	32.97	Good	26	27.65
10	10.63	Fair	29	30.85
0	0	Poor	5	5.31
0	0	Very poor	0	0
33.43		Mean	33.38	
4.791		Std. deviation	7.100	

Table 1 proves that students who responded to the teacher and classmate support questionnaire are "very good" with a percentage value of 56.38. As adolescents, students still need support from teachers and classmates to "legitimize" their existence in learning. Also, they prefer to be treated fairly, kindly, and honestly so that they can reform various potentials to develop more active and expressive physical education learning activities. The presence of teachers and classmates should establish them as guides, helpers, and supporters for students to learn how to avoid negligence. The enrichment of various literature on teacher and classmate support is required to ensure the varied social engineering practices that teachers and classmates practice in learning activities referring to supportive learning cultures. The "very good" trend also applies to the student social self-esteem variable with a percentage value of 36.17. Teacher and classmate support also marks the level of acceptance of students during their learning environment, including feelings of pleasure, being missed, as well as relying on each other for the learning connection in particular tasks. They will be more confident in expressing themselves through their reasoning, attitudes, and performance during learning.

3.2. Regression analysis

After doing a descriptive analysis, the researcher conducted a regression test (t-test). This test aims to see the direction of determination between the variables. This test will provide positive or negative influence evidence as well as the significance level of the two variables.

Table 2 Regression analysis

Model	Unstandardized coefficients	t	Sig	R Square	Description
Constant	5.504	-	-	-	-
teacher and classmate support	0.834	6.531	0.000	0.317	Positive and Significant

The results of statistical testing (see table 2) show that there is a positive and significant influence between teacher and classmate support on students' social self-esteem. This decision is proven through the t-value which is greater than the t-table value (6.531) with a sig value (2-tailed) that is smaller than 0.05 (0.000). Meanwhile, the contribution of teacher and peer support to students' social self-esteem was 0.317. Thus, educators and peers must be able to empower and project supportive learning activities. For example, by treating students in a friendly and fair manner, assisting when students need help, creating togetherness among fellow students, showing social acceptance, and empathizing with fellow students, students feel more comfortable and valuable in expressing themselves during learning without feeling "threatened" by various performances.

4. DISCUSSION

Teacher and classmate support is influential in physical education learning. The main reason is that in physical education learning, the performance of students is manifested clearly in some skills, while it is not very visible for other subjects. Students who have a poor performance may feel embarrassed by peers who have a good performance for these skills are practiced before the audience. The situation will threaten the whole learning atmosphere. If teachers and classmates respond to this performance explicitly, then open comparisons will happen among fellow students. But in fact, teachers should reduce negligence and disparity in students so that they remain enthusiastic during learning. Does negligence need to be corrected? Yes, it needs to be improved, but it must be managed in a more educational way, in which the focus of the improvement is on the students' performance, not the students. Besides, teachers need to prioritize aspects of humanization by first providing support for the works the students produce and for other improvements students need. Thus, when a student needs help from the teacher, he must get it because only the help and support they need to overcome their negligence during learning prevents students from falling for the negligence they did once.

The teacher's fair attitude in treating students is a form of support. The teacher does not differentiate between skilled and unskilled students. All students still treat the teacher well, including giving the same opportunity to demonstrate certain motion tasks. Although in other cases, the skilled students can serve as learning models. However, fair treatment is needed in order to stimulate students so that they indirectly feel they have the ability to do so, although it is not as maximal as the need for certain skill standards.

Students will feel precious because they are welcomed in learning activities by getting equal opportunities. In certain cases, teachers significantly discriminate the unskilled and skilled students in terms of giving opportunities. Teachers seem to close the opportunity for other students to participate, which will lead students to the conclusion that they are being treated unfairly. Physical education learning must provide opportunities for students to move, demonstrate, socialize, express, collaborate, and so forth through physical activities. Thus, support with fair treatment during student movement activities is needed so that they have more opportunities for transformation, while at the same time fostering a sense of self-confidence in front of teachers and classmates.

If we look at the four competency standards for a teacher applied in Indonesia, one of the competencies teachers need to have in carrying out learning is personality competence. According to Blegur, Wasak, & Manu (2017), some of the important indicators in this competency are behaving fairly, friendly, and patiently. Teachers certainly realize that there are a few stories that can stimulate their emotions when carrying out learning. But, as a professional, the teacher must not let these emotions dominate him. Some students do not maximally fulfill or achieve learning objectives; of course, this is disappointing because the teacher is responsible for leading students to achieve learning goals. On the other hand, in a more limited scope, some students do not follow teacher instructions, have low-performance on a task, are unwilling to participate, and so on. Students are unique with their various acts and behaviors, but teachers must still treat them friendly because students only want to be appreciated, accepted, and loved while in the classroom. The negligence of students needs stimulation from the teacher from within by providing support with hospitality, the right treatment, and upholding the learning rights for every student.

Social support has implications for physical (Reblin & Uchino, 2008) and psychological health because social support can moderate genetic and environmental vulnerabilities and provide resistance to stress (Ozbay, Johnson, Dimoulas, Morgan, Charney, & Southwick, 2007). However, research conducted by Eagle et al. showed that one should think about increasing perceptions of social support, either through cognitive framing or positive mental health interventions (Eagle, Hybels, & Proeschold-Bell, 2018). When students feel welcome in the class, then there will be a nuance of solidarity. They are attracted to help each other, not for racial reasons, but more in the aspect of support. If students get support, they will be pleased to share information as well as be involved in togetherness activities inside and outside the classroom. If we look at several cases of bullying that have occurred in the world of education and learning recently, they seem to have occurred due to a loss of support behavior among students. Giving attention only to students who are learning is a real sign of support. There is no need for teachers and colleagues to overthink the material but pay attention to the balance of opportunity, care, and even motivation of students as long as they need it. Some phenomenal students will feel uncomfortable when they are in an unsupportive learning class. What will happen then? They leave various learning activities. For example, they do not want to work in certain groups, or they are even passive while studying particular subjects.

Students getting negative feedback or verbal abuse also interferes with the development of self-esteem, emotional well-being, and physical condition (Noh & Talaat, 2012). This condition is a traumatic experience for students who perform. Students' perceptions of teacher and classmate support will precede the various behaviors they display. If students find that their teachers and classmates support them, they will move forward and carry out movement tasks with joy and enthusiasm. So, every behavior that teachers and

classmates display during learning greatly determines students' perceptions of their behavior. Some students may get permission, medical, and even transfer letters simply because of the discomfort of studying in an intimidating, sarcastic, and destructive classroom. Blegur (2020) has also considered various inequalities in physical education learning, for example, by giving real punishments to students as a form of self-esteem irritation. Based on this, Blegur recommends the "KASIH" method namely: 1) Reduce ridicule for student performance, 2) Appreciate every effort the student has made, 3) Patiently handle every student problem, 4) Remind students of their learning goals, and 5) Avoid comparisons between students. This social self-esteem greatly determines the existence of students in their social community (including class). Therefore, if students have felt irritated regarding their self-esteem in class, they will protect themselves with various things to ensure they are not discriminated against and bullied just because of 'negligence' on certain motion tasks.

Self-esteem is also closely related to social interactions (Widodo & Pratitis, 2013:131). Therefore, teachers need to create a supportive physical education learning culture that is important for the development of students' social self-esteem (Ikiz & Cakar, 2010). One of the essential elements to achieving goals is self-esteem (Doodman, Zadeh, & Changizi, 2017). Indeed, with various engineering, the teacher helps students to achieve goals, and these goals must be transferred onto students so that after learning, students can achieve goals. Social self-esteem can be said to be an element that is currently in crisis. The reason is that various destructive practices do not only come from the internet but the “work” of the teachers themselves. Therefore, the teacher must condemn any excuses used to punish the students in the practice of physical education learning. Physical education teachers must be able to develop supportive and equal learning for every student. Akgul, Cokamay, & Demir (2012) found that teacher support is vital for personal development, academic achievement, and student welfare. Thus, the teacher must ignore the various kinds of discrimination on performance, knowledge, and attitudes the students display. Teachers, at once, are selective in observing student multiple behaviors that cause loss of their social self-esteem.

Although peers can accept students collectively in their class, some of the data showed that students with different ethnicities get different treatment. They are not accepted. It can be stimulated by previous bad acceptance experiences by classmates, which also foster the wrong perceptions of their friends as found in research by Pisula & Łukowska (2011). Teachers can start engineering various social situations for a culture of mutual support between students as an effort to fulfill student self-esteem (Hoffman, Ushpiz, & Levy-Shiff, 1988), as well as suppress parental stress levels on student learning activities (Ati, Matulessy, & Rochim, 2018).

CONCLUSIONS

Both teachers and students need a harmonious and supportive learning climate because they are all in a transitional period trying to realize themselves through learning activities in various forms. Problems that often limit students' freedom of expression are intimidating and discriminatory learning behavior. It appears in the practice of punishment and speech so that it “kills” student expression. Physical education is very susceptible to this. Therefore, supportive behavior from teachers and classmates is highly needed to narrow racial divides among fellow students. Teachers' friendly, fair, and honest behaviors and actions are still necessary for students to maintain them in spaces of

expression and performance both inside and outside the classroom. Physical education must also pay attention to promote humanist learning. Although during practice, it closely relates to a culture of competition.

Teachers can initiate support by always rotating students in study groups across meetings to ensure different levels of student acceptance and cooperation. Because classmate support plays a strategic role in developing self-esteem, then after learning, evaluation activities must also provide a "dynamic" atmosphere so that competitive nuances are only used for certain practices, not for a wide range of things. As a heterogeneous class, the introduction of culture is also needed by teachers and colleagues so that the adaptation process in religion, culture, speech, dialect, etc. is acceptable as a plurality. Thus, social support is always carried out by anyone without having specific racial reasons. With mutual support, students are more ready to express themselves to show their totality in the physical education learning process.

Acknowledgements. *The research team's gratitude goes to Dr. Ir. Ayub U. I. Meko, M.Si., as the rector of Artha Wacana Christian University and Alfred G. O. Kase, M.Si., Ph.D., as the Head of the Research Institute who has sponsored this research activity on the University's Leading Research scheme with the contract number: 44/LP-UKAW/P.10/VIII.2020. We also thank Dr. Johanis W. Kiuk, M.M., as the internal reviewer I and Wilson L. Tisera, M.Si., Ph.D., as the internal reviewer 2 who has selected, facilitated the review and monitored process of research results, and provided recommendations to equip and improve research and publication quality.*

REFERENCES

Aditomo, A., & Retnowati, S. (2004). Perfeksionisme, harga diri, dan kecenderungan depresi pada remaja akhir. *Jurnal Psikologi, 31*(1), 1-14. https://doi.org/10.22146/jpsi.7033

Akgul, G., Cokamay, G., & Demir, E. (2012). Predictors of teacher support: Turkey and Shanghai in the programme for international student assessment, 2012. *Eurasian Journal of Educational Research, 63*, 115-132.

Ati, M. R. S., Matulessy, A., & Rochim, M. F. (2018). The relationship between gratitude and social support with the stress of parents who have children in need of special. *Journal of Child Development Studies*, *3*(1), DOI: https://doi.org/10.29244/jcds.3.1.44-58

Babore, A., Trumello, C., Candelori, C., Paciello, M., & Cerniglia, L. (2016). Depressive symptoms, self-esteem and perceived parent-child relationship in early adolescence. *Frontiers in Psychology*, *7*, 1-7. https://doi.org/10.3389/fpsyg.2016.00982

Blegur, J. (2020). Memperbaiki harga diri siswa dengan metode "KASIH". Dalam Salim, dkk, *Sinergi: Bunga Rampai Kodepena* (83-98). Bandung: Semiotika.

Blegur, J., Mae, R. M., & Souisa, M. (2018). "I feel anxious when communicating: Questioning students' learning readiness". *The 2nd International Conference on Technology, Education, and Social Science 2018 (pp. 75-85)*. Slamet Riyadi University, Surakarta, Indonesia. Retrieved from: http://ejurnal.unisri.ac.id/index.php/proictss/article/view/2142

Blegur, J., Wasak, M. R. P., & Manu, L. (2017). Penilaian formatif peserta didik atas kompetensi pendidik dalam proses pembelajaran. *Satya Widya*, *33*(2), 117-127. https://doi.org/10.24246/j.sw.2017.v33.i2.p117-127

Brockner, J., Derr, W. R., & Laing, W. N. (1987). Self-esteem and reactions to negative feedback: Toward greater generalizability. *Journal of Research in Personality*, *21*(3), 318-333. https://doi.org/10.1016/0092-6566(87)90014-6

Brown, J. D. (2009). High self-esteem buffers negative feedback: Once more with feeling. *Cognition and Emotion*, *24*(8), 1389-1404. https://doi.org/10.1080/02699930903504405

Bruno, U. D. O., & Njoku, J. (2014). The Role of the Teacher in Improving Students Self Esteem. *International Journal of Academic Research in Progressive Education and Development*, *3*(1), 47-53. http://dx.doi.org/10.6007/IJARPED/v3-i1/615

Bum, C-H., & Jeon, I-K. (2016) Structural relationship between students' social support and self-esteem, depression, and happiness. *Social Behavior and Personality: An International Journal*, *44*(11), 1761-1774. Retrieved from https://www.sbp-journal.com/index.php/sbp/article/view/5752

Demaray, M. K., Malecki, C. K., Davidson, L. M., Hodgson, K. K., & Rebus, P. J. (2005). The relationship between social support and student adjustment: A longitudinal analysis. *Psychology in the Schools*, *42*(7), 691-706. DOI: 10.1002/pits.20120

Doodman, P., Zadeh, M. A., & Changizi, B. (2017). Study the relationship between self-esteem and academic achievement among high school students in Lamerd City. *International Journal of Scientific Study*, *5*(3), 221-226. DOI: 10.17354/ijssJuneI/2017/032

Duraku, Z. H., & Hoxha, L. (2018). Self-esteem, study skills, self-concept, social support, psychological distress, and coping mechanism effects on test anxiety and academic performance. *Health Psychology Open*, *5*(2), 1-9. doi: 10.1177/2055102918799963

Eagle, D. E., Hybels, C. F., & Proeschold-Bell, R. J. (2018). Perceived social support, received social support, and depression among clergy. *Journal of Social and Personal Relationships*, *36*(7), 2055-2073. https://doi.org/10.1177/0265407518776134

Ginting, B. O., & Masykur, A. M. (2014). Hubungan antara harga diri dengan asertivitas pada siswa kelas XI SMA Kesatrian 2 Semarang. *Jurnal Empati*, *3*(4), 94-105. Retrieved from: https://ejournal3.undip.ac.id/index.php/empati/article/view/7564

Guess, P. E., & McCane-Bowling, J. (2013). Teacher support and life satisfaction: An investigation with urban, middle school students. *Education and Urban Society*, *8*(1), 30-47. https://doi.org/10.1177/0013124513514604

Hein, V., & Caune, A. (2014). Relationship between Perceived teacher's autonomy support, effort, and physical education. *Kinesiology*, *46*(2), 218-226.

Hidayat, K. (2013). Pengaruh harga diri dan penalaran moral terhadap perilaku seksual remaja berpacaran di SMK negeri 5 Samarinda. *eJournal Psikologi*, *1*(1), 80-87.

Hoffman, M. A., Ushpiz, V., & Levy-Shiff, R. (1988). Social support and self-esteem in adolescence. *Journal of Youth and Adolescence*, *17*, 307-316. https://doi.org/10.1007/BF01537672

Ickes, W. J., Wicklund, R. A., & Ferris, C. B. (1973). Objective self awareness and self esteem. *Journal of Experimental Social Psychology*, *9*(3), 202-219. https://doi.org/10.1016/0022-1031(73)90010-3

Ikiz, F. E., & Ckar, F. S. (2010). Perceived social support and self-esteem in adolescence. *Procedia-Social and Behavioral Science*, *5*, 2338-2342. https://doi.org/10.1016/j.sbspro.2010.07.460

Kerla, M., & Repišti, S. (2013). Socijalno samopoštovanje i interkulturalna osjetljivost kod srednjoškolaca. *Pedagogija*, 3, 451–461

Lawson, J. S., Marshall, W. L., & McGrath, P. (1979). The social self-esteem inventory. *Educational and Psychological Measurement*, *39*(4), 803–811. https://doi.org/10.1177/001316447903900413

Lei, H., Cui, Y., & Chiu, M.M. (2018). The relationship between teacher support and the students' academic emotions: A meta-analysis. *Frontiers in Psychology*, *8*(2288), 1-12. doi: 10.3389/fpsyg.2017.02288

Mackowicz, J. (2013). Verbal abuse in upbringing as the cause of low self-esteem in children. *European Scientific Journal*, *2*, 474-478.

Manna, G., Falgares, G., Ingoglia, S., Como, M. R., Santis, S. D. (2016). The relationship between self-esteem, depression and anxiety: Comparing vulnerability and SCAR model in the Italian context. *Mediterranean Journal of Clinical Psychology*, *4*(3), 1-2.

Mulkam, K. (2016). Hubungan kontrol diri dan harga diri dengan kecerdasan moral siswa SMK Sinar Husni 2 TR Labuhan Deli. *Analitika: Jurnal Magister Psikologi UMA*, *8*(2), 79-89. DOI: http://dx.doi.org/10.31289/analitika.v8i2.866

Nelis, S., & Bukowski, W. M. (2019). Daily affect and self-esteem in early adolescence: Correlates of mean levels and within-Person variability. *Psychologica Belgica: Journal of the Belgian Association for Psychological Science*, *59*(1), 96-115. doi: 10.5334/pb.467

Noh, C. H. C., & Tallat, W. I. A. W. (2012). Verbal abuse on children: Doen in amount to child abuse under the Malaysian law? *Asian Social Science*, *8*(6), 224-228. DOI:10.5539/ass.v8n6p224

Nyarko, K. (2017). Corporal punishment, academic performance and self-esteem among junior high school students in Ghana. *IFE PsycholoIA*, 25(2), 120-132. Retrieved from https://www.ajol.info/index.php/ifep/article/view/162263

Orth, U., Robins, R. W., & Roberts, B. W. (2008). Low self-esteem prospectively predicts depression in adolescence and young adulthood. *Journal of Personality and Social Psychology*, *95*(3), 695-708. DOI: 10.1037/0022-3514.95.3.695

Ozbay, F., Johnson, D. C., Dimoulas, E., Morgan III, C. A., Charney, D., & Southwick, S. (2007). Social support and resilience to stress: From neurobiology to clinical practice. *Psychiatry* (*Edgmont*), *4*(5), 35-40. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2921311/

Pisula, E., & Lukowska, E. (2011). Perception of social relationships with classmates and social support in adolescents with Asperger syndrome attending mainstream schools in Poland. *School Psychology International*, *33*(2), 185-206. https://doi.org/10.1177/0143034311415784

Reblin, M., & Uchino, B. N. (2008). Social and emotional support and its implication for health. Curr Opin Psychiatry, 21(2), 201-205. doi: 10.1097/YCO.0b013e3282f3ad89

Sharma, G. (2016). Teacher support as determinant of academic achievement. *Journal of Educational Research*, *1*(4), 1-9.

Shrauger, J. S., & Rosenberg, S. E. (1970). Self-esteem and the effects of success and failure feedback on performance: *Journal of Personality*, *38*(3), 404-417. https://doi.org/10.1111/j.1467-6494.1970.tb00018.x

Smith, A. N. (2006). The state of research on the effects of physical punishment. *Social Policy Journal of New Zealand*, 27, 114-127.

Toersheim, T., Wold, B., & Samdal, O. (2000). The teacher and classmate support scale: Factor structure, test-retest reliability and validity in samples of 13-and 15-year-old adolescents. *School Psychology International*, *21*, 195-212.

Widodo, A. S., & Pratitis, N. T. (2013). Harga diri dan interaksi sosial ditinjau dari status ekonomi orang tua. *Persona: Jurnal Psikologi Indonesia*, *2*(2), 131-138. DOI: https://doi.org/10.30996/persona.v2i2.100

Yu, R., & Singh, K. (2016). Teacher support, instructional practices, student motivation, and mathematics achievement in high school. *The Journal of Educational Research*, *111*(1), 81-94. https://doi.org/10.1080/00220671.2016.1204260

RAZVIJANJE KULTURE UČENJA FIZIČKOG VASPITANJA KAO VID PODRŠKE RAZVIJANJU SOCIJALNOG SAMOPOUZDANJA UČENIKA

Fizičko vaspitanje je predmet koji od učenika zahteva da budu fizički aktivni pred drugima. Može se steći utisak da je učenik u tim okolnostima podložan kritikama, jer dobija povratne informacije od nastavnika i drugih učenika. Mnogi učenici doživljavaju krizu socijalnog samopoštovanju zbog mogućih propusta u performansi. Cilj istraživanja bio je da se utvrdi nivo podrške nastavnika i drugih učenika razvijanju socijalnog samopoštovanja učenika. U istraživanju učestvovalo je 94 učenika 7 razreda osnovne škole (M = 12,7660; SD = 0,53733). Podaci su prikupljeni pomoću Skale za određivanje podrške nastavnika i drugih učenika i Inventara socijalnog samopoštovanja. Analiza podataka uključila je parametre deskriptivne statistike i t-test. Rezultati pokazuju da podrška nastavnika i drugih učenika utiče na socijalno samopoštovanje učenika tokom fizičkih aktivnosti koje se izvode za vreme časa. Neophodno je prisustvo nastavnika tokom časa kako bi se pružila socijalna, emotivna, i kognitivna podrška učenicima i razvilo njihovo samopouzdanje prilikom iskazivanja svog umeća, kao i samopouzdanje u nastavnom kontekstu i tokom izvođenja ekspresivnih aktivnosti.

Ključne reči: *Fizička kultura, podrška nastavnika, podrška učenika, socijalno samopoštovanje*

FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 20, No 1, 2022, pp. 35 - 45
https://doi.org/10.22190/FUPES210210004S

Research article

EFFECTS OF PLYOMETRIC TRAINING ON BODY COMPOSITION AND MOTOR SKILLS IN FEMALE FOOTBALL PLAYERS

UDC 796.015.132:611-055.2
796.332.012.1-055.2

Mima Stanković, Stefan Đorđević, Ana Lilić, Miljan Hadžović

Faculty of Sport and Physical Education, University of Niš, Niš, Serbia

Abstract. *This paper aims to determine the impact of plyometric training programs of short duration (6 weeks) and high frequency (3 times a week) on the motor skills and body composition of female football players. The total number of participants was 24 female football players, four of whom were excluded due to absence from the final testing (mean value of height 167.53 ± 6.09; and mean value of weight 58.32 ± 8.87). The sample of variables used in the study, to which all the participants were subjected, represents the assessment of body composition, explosive power of the lower extremities, speed, agility, and endurance assessment. The results of the research showed that the six-week program of specific plyometric training for Serbian Super League football players in the basic preparatory period of the season did not affect statistically significant changes in the monitored body composition parameters. Also, the statistically significant changes did not occur in the parameters of explosive power and speed, which was expected according to the age category and level of competition of the participants, which was confirmed by previous research. The changes that occurred with high statistical significance are changes in agility tests with and without a ball as well as in the parameters of cardiorespiratory endurance.*

Key words: *female football players, motor skills, plyometric training, body composition*

INTRODUCTION

In sports such as football, there are a large number of repetitions of activities that require high intensity, such as jumping, changing directions, changing the pace of running, kicking the ball, etc. (Stølen, Chamari, Castagna, & Wisløff, 2005). A large number of

Received February 10, 2021 / Accepted April 27, 2022
Corresponding author: Stefan Đorđević
Faculty of Sport and Physical Education, University of Niš, Čarnojevića 10A, Niš, Serbia
E-mail: stefan.robi.djordjevic@gmail.com

repetitions of high-intensity activity during the 90 minutes of a game requires a high degree of endurance and muscle strength (Stolen et al., 2005). Therefore, one of the most important tasks of the training process in football is the improvement of specific strength, which could be defined as the ability of players to use muscle strength effectively when performing tasks characteristic of a football match (Sporiš, Jovanovic, Krakan, & Fiorentini, 2011).

Several studies highlight the potential advantage of a training processes in which plyometric training is applied (Campo, et al., 2009; Ramirez-Campillo, et al., 2020). Numerous studies have shown that plyometric training leads to positive changes in the field of motor skills in football players (Mohd, et al., 2014; Beato, et al., 2018; Siegler, Gaskill, & Ruby, 2003; Campo, et al., 2009; Ramirez-Campillo, et al., 2016; Ramirez-Campillo, et al., 2020).

Ramirez-Campillo and colleagues (2018) found that plyometric training lasting eight weeks, regardless of frequency, but with the same intensity, has a positive effect on the explosive strength of the legs and endurance in amateurs who play football. Confirmation that the frequency of training is not crucial is obtained when we compare the research conducted by Ozbar and colleagues in 2014 and 2015, which shows that eight weeks of plyometric training (1 time per week) gives approximately equal improvements in assessment tests of explosive leg strength (improvement by 17%) as well as a ten-week training with twice the frequency (an improvement of 21%). Rubley (2011) showed that plyometric training in female football players for 7 weeks with low frequency (1 training per week) does not lead to an improvement in explosive power, while Ozbar and colleagues (2014) found that an eight-week program of the same frequency affects the improvement of explosive power football boots. Ramírez-Campillo and colleagues (2015) confirmed that plyometric training lasting 6 weeks (1 training per week) has a positive effect on the motor skills of female football players, while Chimera (2004) found that the program of the same duration and frequency does not cause statistically significant changes in motor skills. Ramirez-Campillo (2020) with a group of authors in a review study with a meta-analysis showed that the lowest frequency of plyometric training lasts for six weeks, and that it has a moderate impact on the parameters of jumping in female football players.

To our knowledge, in contrast to a large number of papers dealing with the impact of plyometric training on the motor skills of female football players (Mohd, et al., 2014; Beato, et al., 2018; Siegler, Gaskill, & Ruby, 2003; Campo, et al., 2009; Ramírez-Campillo, et al., 2016; Ramirez-Campillo, et al., 2020) there is a much smaller number of papers dealing with the impact of plyometric training on body composition (Campo, et al., 2009; da Silva, et al., 2017; Markovic, et al., 2005).

Campo showed his associates (2009) that a twelve-week training session does not have a significant effect on muscle mass, but that is why it has a large effect on the body fat of football players. Da Silva (2017) found that plyometric training lasting four weeks has a great effect on reducing body fat and increasing muscle mass in athletes who play football.

Based on our literature review, we can see that the results of tests that dealt with the impact of plyometric training on motor skills vary from study to study, and that the number of papers known to us that deal with the impact of plyometrics training on body composition is small. In most studies, the duration of the program is long (8-14 weeks), and the frequency is small (1-2 times a week). This paper aims to determine the impact of plyometric training programs of short duration (6 weeks) and high frequency (3 times a week) on the motor skills and body composition of female football players.

METHODS

The sample of participants

The sample of participants consisted of football players who play in the highest rank of competition, the Serbian Super League. The total number of participants was 24 female football players, four of whom were excluded due to absence from the final testing (mean height 167.53 ± 6.09; and mean weight 58.32 ± 8.87). The inclusion criteria were: injury-free in the last six months, underwent a medical examination, participants who managed to maintain training continuity without absences from training sessions. The exclusion criteria were: persons in the recovery phase from some form of acute and chronic injuries, persons in the process of rehabilitation, and football players who did not complete the training process.

All of the participants were first informed about the study, the purpose, goal, procedure, the course of the test and the possible consequences were explained to them. Before the research, each participant signed a consent form, and after that the testing began. The study was voluntary and each of the participants could withdraw from the study at any time during the testing.

The research was approved by the Ethics Committee of the Faculty of Sports and Physical Education, University of Nis in accordance with the Declaration of Helsinki.

Procedures

The sample of variables used in the study, to which all the participants were subjected, represents the assessment of body composition, explosive power of the lower extremities, speed, agility and endurance assessment. In the morning, before the test, the participants did not consume food and beverages. Due to technical reasons, i.e. the impossibility of transferring equipment, testing of the variables used to assess body composition and explosive power of the lower extremities was done indoors, in the room where the instruments are located. The power assessment tests were preceded by a standardized warm-up that included moderate-intensity running (5 min), and static and dynamic stretching (5 min). Field tests used to assess speed, agility, and endurance were preceded by a 15-minute warm-up, a 10-minute run and dynamic warm-up, and a 5-minute dynamic stretch. The same protocol was applied in both the initial and final testing.

The assessment of body composition and strength was determined in the morning (10 am). It included the assessment variables of body height (cm), body weight (kg), while body fat, lean body mass, muscle mass, segmental analysis of the right and left legs were measured in absolute and relative values. Also, the results of the body mass index (BMI) were noted. Body height was measured using a portable anthropometer (Seca 220, Seca Corporation, Hamburg, Germany) with an accuracy of 0.1 cm. Other body composition values were obtained using InBody 770 (Aandstad, Holtberget, Hageberg, Holme, & Anderssen, 2014). The percentage of muscle mass was obtained using the formula MM% = MM kg / body weight (kg). The percentage of lean body mass was obtained using the formula NTM% = NTM kg / body weight (kg).

The tests used to assess the explosive power of the lower extremities are: the countermovement jump (CMJ), countermovement jump with free arms (CMJA), and squat jumps (SJ).

The *countermovement jump test* was measured using Optojump (Glatthorn et al. 2011). Jump values were obtained by placing the participant in a confined space encompassed by

Optojump sensors. From an upright position, on the invigilator's signal, the participant with hands on hips, goes into a half-squat and from that position jumps as high as possible. If the participant makes a mistake during the performance, the performance is repeated. It was necessary for the participant to perform three technically correct jumps. The best result was taken for analysis.

The *countermovement jump with free arms* is a test that also assesses the explosive power of the lower extremities, only differing in that in this test the hands are free next to the body. It was necessary for the participant to perform three technically correct jumps. The best result was taken for analysis. It was also measured using the Optojump sensor (Glatthorn et al. 2011). The squat jumps test was performed by the participant assuming the starting position in a half squat with hands on hips. At the sign of the invigilator, the participant takes off from the starting position in a vertical jump. Each test was repeated three times, and the best achieved values were taken for analysis. Jump values are displayed on the screen using Optojump sensors (Glatthorn et al. 2011).

Sprint speed at 10m, 20m, 30m

The participant starts from a high start at the moment when she assesses that she is ready and sprints across the entire 30m track with a passing time of 10m, 20m and 30m (Delextat & Cohen, 2009).

The T-test

The participants had the task of crossing the path between the four bases (A, B, C and D) set in the shape of the letter T in the shortest possible time. The total distance traveled was 40 meters, and the time measurement began and ended at base A. From the start line, the participant runs as fast as she can straight ahead - to base B and touches the base with her right hand, then turns left and runs to base C (touches the base with her left hand), then turns and runs to base D (touches the base with her right hand), turns and runs back towards cone B touches the base on her left hand, turns left and runs to the goal (base A) (Pauole, Madole, Garhammer, Lacourse & Rozenek, 2000).

The „505" running test

The participants had the task of crossing the distance between markers 15 m apart in the shortest possible time. The participants tried to achieve maximum acceleration from the starting line to, and then to stop the curves of the second marker, turn 180° and run again, maximally accelerating the valleys to the finish (5 m). The total previous path in this task is 20 meters (Draper & Lancaster, 1985).

The 9-6-3-6-9 test with a 180° turn

It is used to estimate the speed of changing direction of movement with the given rotations around the axis of the body by 180°, with an emphasis on frontal agility. The participant assumes a high start position so that her chest is facing the goal. At the invigilator's signal, she starts running at maximum speed to the line 9m away from the start, touches the line with her foot, turns 180º and continues running (chest turned towards the starting line) to the line 6m away from the start. She touches the line again, turns a second time and continues running to the line 12 m from the start. She touches the line once more,

turns for a third time for 180º and continues to run to the line 9 m away from the start. On that line, for the fourth time, she changes the direction of movement by 180º. The task is completed when the participant, running at maximum speed, passes the imaginary finish line with her chest (18 m away from the start). (Sporis, Jukic, Milanovic & Vucetic, 2010).

The 4x5m sprint

The test consisted of a constant change of direction that the players had to perform. Five bases were placed at a distance of 5 m. The participants stood feet apart and with the bases between their legs. Each player started after the beep and ran 5 m from point A to point B. After reaching point B, she turned 90 degrees to the right and then moved 5 m to point C. At point C, she made a 90° turn and ran to point D, where she turned 180° and ran overtaking E (finish line). The same test was repeated with a ball. (Sporis, Jukic, Milanovic & Vucetic, 2010).

Yo-yo Intermittent Recovery Test 2

The test is used to assess the rate of recovery during intense acyclic activity of an aerobic-anaerobic character. At the sound signal from a CD player, all players run to a cone 20 m away (mark B) and back to the start. Upon arrival at the start, the participants have a 10-second break during which they must run slowly to a third cone (mark C) 5 m away and return. At a new signal, the running is repeated. Running speed increases progressively. The test is interrupted when the participant fails to run the section twice in a row, at the set speed. The result of the test is the total run section in meters (Bangsbo, Iaia & Krustrup, 2008)

Running without and with a ball is used to assess the agility and skill of running with a ball. The participant from the high start position, after a visual signal, has the task of running the set zigzag track with a total length of 20 m as fast as possible. The participant occupies the same position as in the previous case, but with a soccer ball next to the foot that is closer to the starting line. She repeats the previous task, this time leading the ball (Little & Williams, 2005; Mirkov, Nedeljkovic, Kukolj, Ugarkovic & Jaric, 2008).

Experimental treatment

The participants were exposed to six weeks of plyometric training (Table 1). Although all the football players had previous experience in this type of training, the training instructor gave instructions and practically demonstrated the manner and technique of performing each exercise before each training. Plyometric training was held after 15 minutes of warm-up at the beginning of the training, three days a week.

Part of the plyometric training lasted 40-45 minutes after training, and the training regime was based on three different exercises. Exercise 1 and Exercise 2 were done in 4 series with a break between series of 30 seconds and a break between exercises of 40 seconds. Exercise 3 was done in two series and with a break of 4 minutes between series.

Table 1 Plyometric training program

			Monday	Wednesday	Friday
Number per week	Number for six weeks	Exercise	Warm up: 15`	Warm up: 15`	Warm up: 15`
			Plyometric training: 40-45`	Plyometric training: 40-45`	Plyometric training: 40-45`
15	90		*Exercise 1:* A series of 5 jumps over obstacles of 50 cm high, the distance between the obstacles is 45 cm.	*Exercise 1:* A series of 5 jumps over obstacles of 50 cm high, the distance between the obstacles is 45 cm.	*Exercise 1:* A series of 5 jumps over obstacles of 50 cm height, the distance between the obstacles is 45 cm.
15	90		*Exercise 2:* A series of 5 jumps, sun jumps, over an obstacle 20 cm high, the distance between the obstacles is 30 cm.	*Exercise 2:* A series of 5 jumps, sun jumps, over an obstacle 20 cm high, the distance between the obstacles is 30 cm.	*Exercise 2:* Series of 5 jumps, sun jumps, over an obstacle of 20 cm height, distance between obstacles is 30 cm
36	216		*Exercise 3:* A series of 12 jumps on a box 40 cm high.	*Exercise 3:* A series of 12 jumps on a box 40 cm high.	*Exercise 3:* A series of 12 jumps on a box 40 cm high
			The main part: 35-40` TE/TA exercise	The main part: 45` Play in a shortened space	The main part: 25-30` TA exercise

Legend: TE - technique exercises; TA - tactical exercises

Statistical data processing

For data processing and analysis, the statistical package for data processing SPSS 20 was used (IBM Corporation; Armonk, NY, USA). The Kolmogorov-Smirnov test was performed first to examine the normality of the distribution of results. The basic parameters of descriptive statistics for each variable were calculated. The basic descriptive parameters were: arithmetic mean (Mean), standard deviation (Std.Dev.), minimum value (Min), maximum value (Max). To determine the differences, we used a two-way ANOVA (group x time) with repeated measurements. Also, an effect size was done to determine the magnitude of the impact.

3. RESULTS

Based on the results presented in table 2, which describes the differences between the initial and final measurements within the variables describing the body composition of the participants, it can be seen from the statistical analysis of the repeated-measures T-test that there is no statistically significant difference between the values at the initial and

final measurements in almost any of the variables. The analysis that calculates the effect size also did not show a greater impact in any variable other than the trivial.

Table 2 The differences between the parameters of body composition at the initial and final measurement

Variables	I (M ± SD)	F (M ± SD)	p	Cohen Effect Size ES (95% CI)
IH(cm) – FH(cm)	167.53 ± 6.09	167.68 ± 6.16	.083	-0.03 (-0.66 to 0.61)[T]
IW(kg) – FW(kg)	58.32 ± 8.87	58.68 ± 8.81	.227	-0.04 (-0.68 to 0.60) [T]
IBMI - FBMI	20.84 ± 2.41	20.83 ± 2.33	.920	0.00 (-0.63 to 0.64) [T]
IFMkg(kg) – FFMkg(kg)	12.43 ± 4.35	12.62 ± 4.33	.483	-0.04 (-0.68 to 0.59) [T]
IFMp(%) – FFMp(%)	20.90 ± 5.10	21.22 ± 5.24	.466	-0.06 (-0.70 to 0.58) [T]
ILBMkg(kg) – FLBMkg(kg)	45.62 ± 4.63	46.07 ± 5.91	.402	-0.09 (-0.72 to 0.55) [T]
ILBMp(%) – FLBMp(%)	78.93 ± 6.21	78.79 ± 5.23	.889	0.02 (-0.61 to 0.66) [T]
IMMkg(kg) – FMMkg(kg)	25.32 ± 3.47	25.41 ± 3.49	.401	-0.03 (-0.66 to 0.61) [T]
IMMp(%) – FMMp(%)	43.61 ± 2.87	43.42 ± 2.90	.373	0.07 (-0.57 to 0.70) [T]
ISARLkg(kg) – FSARLkg(kg)	7.3 ± 0.96	7.46 ± 1.01	.140	-0.07 (-0.70 to 0.57) [T]
ISARLp(%) – FSARLp(%)	112.93 ± 6.16	112.84 ± 6.61	.911	0.01 (-0.62 to 0.65) [T]
ISALLkg(kg) – FSALLkg(kg)	7.30 ± 0.94	7.37 ± 0.98	.068	-0.08 (-0.71 to 0.56) [T]
ISALLp(%) – FSALLp(%)	111.54 ± 6.52	111.77 ± 6.46	.684	-0.04 (-0.67 to 0.60) [T]

Legend: N - Number of participants; cm - centimeters; kg - kilograms; % - percentage; IH - Height of the participants at the initial measurement; IW - Weight of the participants at the initial measurement; IBMI - Body Mass Index at the initial Measurement; IFMkg - Body fat in kilograms at the initial measurement; IFMp - Body fat percentage at the initial measurement; ILBMkg - Lean body mass in kilograms at the initial measurement; ILBMp - Lean body mass percentage at the initial measurement; IMMkg - Muscle mass in kilograms at the initial measurement; IMMp - Muscle mass percentage; ISARLkg - Segmental analysis of the right leg in kilograms at the initial measurement; ISARLp - Segmental analysis of the right leg in percentages at the initial measurement; ISALLkg - Segmental analysis of the left leg in kilograms at the initial measurement; ISALLp - Segmental analysis of the left leg in percentages at the initial measurement; FH - Height of the participants at the final measurement; FW - Weight of the participants at the final measurement; FBMI - Body Mass Index at the final measurement; FFMkg - Body fat in kilograms at the final measurement; FFMp - Body fat percentage at the final measurement; FLBMkg - Lean body mass in kilograms at the final measurement; FLBMp - Non-fat body mass percentage at the final measurement; FMMkg - Muscle body mass in kilograms at the final measurement; FMMp - Muscle body mass percentage at the final measurement; FSARLkg - Segmental analysis of the right leg in kilograms at the final measurement; FSARLp - Segmental analysis of the right leg in percentages at the final measurement; FSALLkg - Segmental analysis of the left leg in kilograms at the final measurement; FSALLp - Segmental analysis of the left leg in percentages at the final measurement; p - Statistical significance of the difference between the initial and final measurement; I - Initial measurement; F - Final measurement; M - Mean value; SD - deviation from the mean value, ES = effect size; CI = confidence interval, T - Trivial, <0.2.

Based on the results presented in table 3, which describes the differences between the initial and final measurement within the variables describing the motor space, it can be seen that there is a statistically significant difference between the initial and final measurement of the participants. A statistically significant difference determined by the repeated-measures T-test was found for the variables: CMJa (r = 0.00), while the analysis of the effect size showed a small effect size (-0.57 (-1.20 to 0.09)); 505 (r = 0.00), a very large effect size (3.74 (2.62 to 4.70); 96369 (r = 0.03), a small effect size (-0.44) (-1.07 to 0.21)); T test (r = 0,00), a medium effect size (0.84 (0.16 to 1.48)); CIKCAK (r = 0,00), a medium effect size (0.85 (0.17 to 1.50)); CYCLE (r = 0.00), a medium effect size (0.99 (0.29 to 1.64)); YOYOd (r = 0.00), a large effect size (-1.52 (-2.21 to -0.77)); VO2MAX (ml / min / kg) (r = 0.00), and a large effect size (-1.60 (-2.30 to -0.84) There were no

statistically significant differences between the initial and final measurements in the other variables at the final measurement for the motor abilities.

Table 3 Difference between the parameters of motor abilities at the initial and final measurement

Variables	I (M ± SD)	F (M ± SD)	p	Cohen Effect Size ES (95% CI)
ICMJ(cm)–FCMJ(cm)	23.88 ± 3.28	24.77 ± 3.15	0.09	-0.28 (-0.91 to 0.37)^{M}
ICMJa(cm)–FCMJa(cm)	26.79 ± 4.00	28.98 ± 3.73	0.00	-0.57 (-1.20 to 0.09)^{M}
ISJ(cm)–FSJ(cm)	22.29 ± 2.85	22.97 ± 2.85	0.24	-0.24 (-0.87 to 0.40)^{M}
IS10m(s)–FS10m(s)	2.02 ± 0.09	2.04 ± 0.22	0.70	-0.12 (-0.76 to 0.52)^{T}
IS20m(s)–FS20m(s)	3.53 ± 0.14	3.57 ± 0.15	0.46	-0.27 (-0.90 to 0.38)^{M}
IS30m(s)–FS30m(s)	4.97 ± 0.21	5.05 ± 0.35	0.19	-0.29 (-0.92 to 0.36)^{M}
I505(s) - F505(s)	4.65 ± 0.20	3.94 ± 0.18	0.00	3.74 (2.62 to 4.70)^{VV}
I96369(s) - F96369(s)	8.03 ± 0.43	8.23 ± 0.47	0.03	-0.44 (-1.07 to 0.21)^{M}
ITtest(s)– FTtest(s)	10.97 ± 0.40	10.65 ± 0.35	0.00	0.84 (0.16 to 1.48)^{U}
ICIKCAK(s)– FCIKCAK(s)	5.76 ± 0.24	5.56 ± 0.22	0.00	0.85 (0.17 to 1.50)^{U}
ICIKCAKL(s)– FCIKCAKL(s)	7.85 ± 0.55	7.29 ± 0.59	0.00	0.99 (0.29 to 1.64)^{U}
I4X5M(s) - F4X5M(s)	6.21 ± 0.27	6.29 ± 0.20	0.19	-0.33 (-0.96 to 0.32)^{M}
I4X5ML(s) - F4X5ML(s)	8.19 ± 0.62	8.11 ± 0.55	0.55	0.14 (-0.50 to 0.78)^{T}
IYOYOd(m)– FYOYOd(m)	1272.11±364.40	1885.26±437.56	0.00	-1.52 (-2.21 to -0.77)^{V}
IVO2MAX(ml/min/kg) – FVO2MAX(ml/min/kg)	47.01 ± 2.98	52.39 ± 3.71	0.00	-1.60 (-2.30 to -0.84)^{V}

Legend: N - Number of respondents; m. Meter; cm - Centimeter; s - Seconds; kg - Kilogram; min - Minute; ml - Mol; ICMJ - Vertical jump with a swing on the initial measurement; ICMJa - Vertical jump with a swing and free hands on the initial measurement; ISJ - Vertical squat jump on initial measurement; IS10m - Running speed at 10 meters at the initial measurement; IS20m - Running speed at 20 meters on the initial measurement; IS30m - Running speed at 30 meters at the initial measurement; I505 - 505 agility test on initial measurement; I96369 - Agility test 9-6-3-6-9 on initial measurement; ITtest - T test on initial measurement; ICIKCAK - CIKCAK test on initial measurement; ICIKCAKL - Test ZIKCAKL with a ball on the initial measurement; I4X5M - 4x5 meter test on initial measurement; ; I4X5ML - 4x5 meter test with ball on initial measurement; IYOYOd - Test YOYO length run on initial measurement; IVO2MAX - Maximum oxygen consumption at initial measurement; FCMJ - Vertical rocking jump on the final measurement; FCMJa - Vertical jump with a swing and free hands on the final measurement; FSJ - Vertical squat jump on the final measurement; FS10m - Running speed at 10 meters on the final measurement; FS20m - Running speed at 20 meters on the final measurement; FS30m - Speed of running at 30 meters on the final measurement; F505 - 505 agility test on final measurement; F96369 - Agility test 9-6-3-6-9 on final measurement; FTtest - T test on the final measurement; FCIKCAK - CIKCAK test on the final measurement; FCIKCAKL - Test ZIKCAKL with the ball on the final measurement; F4X5M - 4x5 meter test on the final measurement; F4X5ML - 4x5 meter test with ball on final measurement; FYOYOd - Test YOYO length run on the final measurement; FVO2MAX - Maximum oxygen consumption at the final measurement; p - Statistical significance of the difference between the initial and final measurement; I - Initial measurement; F - Final measurement; M - Mean value; SD - deviation from the mean value; ES = effect size; CI = confidence interval, T - Trivial, <0.2; M - Small, 0.2–0.59; U - Moderate, 0.6–1.19; V - Great, 1.2–1.99; VV - Very large,> 2.

DISCUSSION

The results obtained in this study indicate that plyometric training lasting 6 weeks, three days a week does not significantly affect the body composition of the participants. The same result was obtained in one of the previous studies analyzed in this paper (Campo, et al., 2009). In that research, the participants were also football players, with

the difference that their plyometric training program lasted twice as long, but there was also no statistically significant effect of plyometric training on body composition.

Plyometric training has been recommended as a good alternative to strength training for the lower extremities (Myer, Ford, Palumbo, & Hewett, 2005). It is very often applied in the preparatory period in order to bring the players into a satisfactory form. Such work in the preparatory period can lead to an improved performance of football players, such as increasing muscle strength and endurance.

It has been found that programs applied three times a week for six to ten weeks have a better effect compared to other plyometric training programs (Ozbar, Ates, & Agopyan, 2014). Although the program applied in this study was within the recommended values, i.e. it was applied three times a week for 6 weeks, not all the tests achieved the desired effect. Specifically, no significant difference between the initial and final measurements was observed in the speed estimation tests.

Speed as a motor ability is very important skill in football. High-speed players have an advantage over others when it comes to getting the ball or taking the ball away from the opponent. Plyometric training has been marked as adequate for speed development in a review of previous works (De Villarreal, Requena, & Cronin, 2012). Nevertheless, the participants did not achieve significantly better results at the final measurement after the applied training program on the tests for determining the speed of S10, S20 and S30, which further implies that plyometric training in this case did not affect speed. The results obtained differ from the results in some previous studies (Beato, et al., 2018; Fischetti, Cataldi, & Greco, 2019), there are studies in which speed also did not improve significantly after plyometric training (Jeong, 2005; Lee, Ha, Ju, & Lee, 2019).

However, when it comes to motor skills tests, the research showed that the training program had an impact on the results of certain tests. The obtained results indicate that plyometric training had a statistically small effect on the results of the CMJ test. As the CMJ test is used to evaluate the explosive strength of the legs, it can be concluded that plyometric training has a positive effect on the explosive strength of the legs, i.e. muscle strength, and at the same time on the football players' jumping abilities. Such results have been obtained in some other studies (Mohd, Kamaruzaman, Syed Ali, & Kamar, 2014; Beato, et al., 2018; Chimera, Swanik, Swanik, & Straub, 2004).

An effect of plyometric training on the 505, T-test, and 96369 test was also observed. All of these tests are used to determine agility. As agility is defined as a combination of speed and explosive power, we can conclude that plyometric training affects the development of speed and explosive power in female football players. This resulted in better results on agility tests after 6 weeks of applied training. Beato and his associates (2018) also showed that plyometric training has a positive effect on the development of agility. Fischetti (2019) used the T-test to assess agility and obtained results that indicated that plyometric training had a positive effect on test results.

On the CIKCAK and CIKCAKL tests, better results were also achieved at the final measurement compared to those at the initial measurement. These two tests, in addition to assessing the agility of the participants, were also used to determine the level of the specific football technique in football players. Based on the results obtained, we can conclude that plyometric training after 6 weeks had a positive impact on the level of the specific football technique. The results obtained indicate that plyometric training fulfills one of the most important tasks of the training process of football players, and that is the improvement of specific strength (Bangsbo, 1994).

The results obtained showed that the plyometric training for a period of 6 weeks also had an impact on the endurance of a female football players, i.e. the effect size analysis observed large effects for the YOYOd and VO2MAX tests. Previous research analyzed in this paper studied the effects of plyometric training with regular training sessions 2 times a week for six weeks on endurance (Ramírez-Campillo et al., 2015). The results obtained also showed that plyometric training has a positive effect on the endurance of the participants.

CONCLUSION

The results of the research showed that a six-week program of specific plyometric training for Serbian Super League football players during the basic preparatory period of the season did not affect statistically significant changes in the studied body composition parameters. Also, statistically significant changes did not occur in the parameters of explosive power and speed, which was expected based on the age category and level of competition of the participants, and confirmed by previous research. The changes that occurred with high statistical significance are changes in agility tests with and without a ball, as well as in the parameters of cardiorespiratory endurance. In line with the obtained results, this study will certainly be useful for coaches and football players in the senior category in an attempt to determine the optimal strategy for increasing training for the basic preparatory period of the season.

REFERENCES

Bangsbo, J. (1994). The physiology of soccer: with special reference to intense intermittent exercise. Acta Physiologica Scandinavica, 151(619), 156.

Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer: An update. Sports Medicine, 35(6), 501–536.

Datson, N., Hulton, A., Andersson, H., Lewis, T., Weston, M., Drust, B., & Gregson, W. (2014). Applied physiology of female soccer: An update. *Sports Medicine*, 44(9), 1225–1240.

Mohd, M., Kamaruzaman, S.,Syed Ali, S., & Kamar, S. (2014). The effectiveness of plyometric training on muscle strenght for soccer players. Science, Movement and Health, 14(2), 279-285.

Beato, M., Bianchi, M., Coratella, G., Merlini, M., & Drust, B. (2018). Effects of plyometric and directional training on speed and jump performance in elite youth soccer players. *The Journal of Strength & Conditioning Research*, 32(2): 289–296.

Campo, S., Vaeyens, R., Philippaerts, R., Redondo, J., de Bento, A., & Cuardado, G. (2009). Effects of lower-limb plyometric training on body composition,explosive strength, and kicking speed in female soccer players. Journal of Strength and Conditioning Research, 23(6), 1714-1722.

Ramírez-Campillo, R., Vergara-Pedreros, M., Henríquez-Olguín, C., Martínez-Salazar, C., Alvarez, C., Nakamura, F., De La Fuente, C., Caniuqueo, A., Alonso-Martinez, A., & Izquierdo, M. (2015). Effects of plyometric training on maximal-intensity exercise and endurance in male and female soccer players. *Journal of Sports Sciences*, 34(8), 687-693.

Glatthorn, J. F., Gouge, S., Nussbaumer, S., Stauffacher, S., Impellizzeri, F. M., & Maffiuletti, N. A. (2011). Validity and reliability of Optojump photoelectric cells for estimating vertical jump height. *The Journal of Strength & Conditioning Research*, 25(2), 556-560.

Aandstad, A., Holtberget, K., Hageberg, R., Holme, I., & Anderssen, S. A. (2014). Validity and reliability of bioelectrical impedance analysis and skinfold thickness in predicting body fat in military personnel. *Military Medicine*, *179*(2), 208-217.

Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability and validity of the T-test as a measure of agility, leg power, and leg speed in college-aged men and women. *The Journal of Strength & Conditioning Research*, *14*(4), 443-450.

Draper, J. A., & Lancaster, M. G. (1985). The 505 test: A test for agility in the horizontal plane. *Australian Journal for Science and Medicine in Sport*, 17(1), 15-18.

Sporis, G., Jukic, I., Milanovic, L., & Vucetic, V. (2010). Reliability and factorial validity of agility tests for soccer players. *The Journal of Strength & Conditioning Research*, *24*(3), 679-686.

Bangsbo, J., Iaia, F. M., & Krustrup, P. (2008). The Yo-Yo intermittent recovery test. *Sports Medicine*, *38*(1), 37-51.

Little, T., & Williams A.G.. (2005). Specificity of acceleration, maximum speed, and agility in professional soccer players. *Journal of Strength and Conditioning Research*, 19(1), 76–78.

Mirkov, D.M., Nedeljković, A., Kukolj, M., Ugarković, D., & Jarić, S. (2008). Evaluation of the reliability of soccer-specific field tests. *Journal of Strength and Conditioning Research*, 22(4), 1046–1050.

Sporis, G., Jukic, I., Milanovic, L., & Vucetic, V. (2010). Reliability and factorial validity of agility tests for soccer players. *The Journal of Strength & Conditioning Research*, *24*(3), 679-686.

Delextrat, A., & Cohen, D. (2009). Strength, power, speed, and agility of women basketball players according to playing position. *The Journal of Strength & Conditioning Research*, 23(7), 1974-1981.

Marković, G., Jukić, I., Milanović, D. & Metikoš, D. (2005). Effects of sprint and plyometric training on morphological characteristics in physically active men. *Kinesiology*, 37(1), 32-39.

Siegler, J., Gaskill, S., &Ruby, B. (2003). Changes evaluated in soccer-specific power endurance either with or without a 10-week, inseason, intermittent, high-intensity training protocol. *The Journal of Strength & Conditioning Research*, 17(2), 379–87.

Campo, S.S., Vaeyens, R., Philippaerts, R.M, et al. (2009) Effects of lowerlimb plyometric training on body composition, explosivestrength and kicking speed in female soccer players. *The Journal of Strength & Conditioning Research*, 23(6), 1714–1722.

EFEKTI PLIOMETRIJSKOG TRENINGA NA TELESNU KOMPOZICIJU I MOTORIČKE VEŠTINE FUDBALERKI

Cilj ovog rada bio je utvrditi efekte kratkotrajnog (6 nedelja) i visoko frekventnog (3 puta nedeljno) pliometrijskog treninga na motoričke sposobnosti i telesnu kompoziciju fudbalerki. Ukupan broj ispitanica u ovoj studiji bio je 24, od kojih su četiri isključene zbog izostanka sa finalnog testiranja (srednja vrednost visine 167.53 ± 6.09; srednja vrednost težine 58.32 ± 8.87). Uzorak varijabli korišćenih u istraživanju, kom si pristupile sve ispitanice, predstavlja procenu telesne građe, eksplozivne snage donjih ekstremiteta, brzine, agilnosti i izdržljivosti. Rezultati istraživanja su pokazali da šestonedeljni program specifičnog pliometrijskog treninga za fudbalerke Superlige Srbije u pripremnom periodu sezone nije uticao na statistički značajne promene praćenih parametara telesne kompozicije. Takođe, nisu se desile statistički značajne promene u parametrima eksplozivne snage i brzine, što je bilo očekivano prema starosnoj kategoriji i stepenu takmičenja ispitanica, što je potvrđeno prethodnim istraživanjem. Promene koje su se desile sa visokim statističkim značajem su promene u testovima agilnosti sa i bez lopte, kao i u parametrima kardiorespiratorne izdržljivosti.

Ključne reči: *fudbal, motorika, pliometrija, telesni sastav*

FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 20, No 1, 2022, pp. 47 - 59
https://doi.org/10.22190/FUPES220216005S

Research article

THE RELATIONSHIP BETWEEN JUMP PERFORMANCE, SPEED AND COD SPEED IN ELITE FEMALE SOCCER PLAYERS

UDC 796.015.52-055.2
796.332.012.13-055.2

Mima Stanković[1], Dušan Đorđević[1], Andrea Aleksić[1], Anja Lazić[1], Ana Lilić[1], Ilma Čaprić[2], Nebojša Trajković[1]

[1]Faculty of Sport and Physical Education, University of Niš, Niš, Serbia
[2]Faculty of Sport and Physical Education, State University of Novi Pazar, Serbia

Abstract. *The purpose of this study was to present the physical performance of elite female soccer players and to analyze the relationship between jump performance, speed and COD ability. Sixteen elite female soccer players (age: 20.05±2.85; height: 166.47±4.83cm; body weight: 60.52±8.30kg, BMI 21.88±2.86) from a women's club who played the highest rank of the competition took part in this study. The jump, speed and COD abilities of each player were determined using: (1) the Squat jump (SJ), (2) Countermovement Jump (CMJ), countermovement jump with arm swing (CMJA), (2) running speed at 30-m with passing time at 10m and 20m, (3) the pro agility test (pro), (4) zig-zag test (zig-zag), (5) 9-6-3-6-3 sprint (9-6-3-6-9). The results of Pearson's correlation indicated moderate significant relationships between the 10m running speed and pro agility test (r=0.59; p<0.01), as well as the zig-zag test (r=0.55; p<0.01), and also between the 30m and all COD tests (pro agility r=0.66; p<0.01, zig-zag r=0.59; p<0.01 and 9-6-3-6-9 r=0.58; p<0.05). A small correlation (r=0.49; p<0.03) was noticed between the 10m running test and 9-6-3-6-9 agility test, and also between the CMJA (r=0.45; p<0.05) and the 9-6-3-6-9 agility test. The findings of the present study indicated a significant correlation between speed and all of the COD tests, additionally between the CMJA and 9-6-3-6-9 COD test. Therefore, elite female soccer players with higher maximum acceleration rates and speed tend to perform better in change of direction tests. On the other hand, jump performance does not significantly correlate with COD ability.*

Key words: *Team Sport, Agility, Field-Testing, Explosive Power*

Received February 16, 2022 / Accepted April 11, 2022
Corresponding author: Dušan Đorđević
Faculty of Sport and Physical Education, University of Niš, Čarnojevića 10A, Niš, Serbia
E-mail: dusandjordjevic1995@gmail.com

INTRODUCTION

In the last two decades, women's soccer has developed significantly in terms of quality, which includes better fitness performances and more attractive moves, and quantity, regarding the higher number of matches played during the season and players involved (Hovden, 2012). Therefore, the demands of women's soccer have risen sharply (Martínez-Lagunas, Niessen, & Hartmann, 2014). Today, female soccer players are required to perform more explosive movements, cover greater distances, make changes in intensity and direction (Datson et al., 2017; Milanović et al., 2017). According to Fields, Esco, Merrigan, White, & Jones (2020) the primary goal of training in women's soccer is to achieve optimal performance improvement.

Explosive actions such as jumping, accelerating, deceleration, various sprints with changes of direction (Marcelino et al., 2016) and the ability to repeat these actions identically in competition are key to success in team sports such as soccer (Romero-Moraleda et al., 2021). Furthermore, these explosive actions, such as sprinting, jumping, tackling, and change of direction (COD) have a direct effect on the result of the match (Loturco, Jeffreys, et al., 2020).

COD is a complex skill which is usually defined as the ability to make sudden changes of direction (Chaouachi et al., 2012) and it is conditioned by a large number of different factors, such as linear speed, running technique, strength, and the quality and strength of the leg muscles (Dos'Santos, Thomas, Comfort, & Jones, 2018). Most high-intensity activities take place during crucial moments, such as competitions, offensive and defensive actions, as well as goal-scoring opportunities (Griffin et al., 2020; Strauss, Sparks, & Pienaar, 2019). During one soccer match, players perform numerous sprints with different COD, as well as a large number of jumps and sprints (Trewin, Meylan, Varley, & Cronin, 2018). The ability to change direction is essential for an athlete's success in being able to respond to tasks at different stages of development and in different positions in the game (Brughelli, Cronin, Levin, & Chaouachi, 2008; Goral, 2015; Mujika, Santisteban, Impellizzeri, & Castagna, 2009).

During the performance of COD movement, there are two different types of muscular actions as the body quickly slows down (eccentric action) and accelerates (concentric action) during movement (Chaabene, Prieske, Negra, & Granacher, 2018). Given the possibility of sudden changes of direction, it is considered that COD is a valid way to assess the fitness of soccer players of different ages, genders, and competitive levels (Reilly, Bangsbo, & Franks, 2000). It is known that professional athletes are able to make better use of their linear sprint capacity over curvilinear paths, possibly through optimized inner leg performance and a superior ability to cope with high centripetal forces (Filter et al., 2020; Loturco, Pereira, et al., 2020). Also, muscle strength and the ability to accelerate can determine COD in a population of elite soccer players (Chaouachi et al., 2012). The relation between these abilities may be explained by the fact that sprinting and jumping both require the application of considerable amounts of vertical force onto the ground to rapidly accelerate the body vertically or forward (Colyer, Nagahara, Takai, & Salo, 2018).

There are several studies that analyzed the relationship between different parameters and COD ability in men's soccer (Çinarli, Kafkas, & Kafkas, 2018; R. Hammami, Granacher, Pizzolato, Chaouachi, & Chtara, 2017; Loturco, Jeffreys, et al., 2020; Raya-González et al., 2020), while few authors investigated female soccer players (Kobal et al., 2021; Lockie, Dawes, & Jones, 2018; Pardos-Mainer et al., 2021) or other female athletes, such as volleyball, handball, basketball, and softball players (Banda, Beitzel, Kammerer, Salazar, & Lockie, 2019; Lockie,

Dawes, & Callaghan, 2020; Nimphius, Mcguigan, & Newton, 2010; Pereira et al., 2018). The results of the mentioned studies had inconsistent and heterogeneous results. Lockie et al. (2018) investigated how linear speed and leg power may influence COD ability in NCAA Divisions I and II women soccer players and found divergent results. In the Division I players, the modified T-test (MTT) did not significantly relate to the 10m sprint or any of the jump variables (r=0.18), while the 505 test positively correlated with the 10m sprint (r=0.35), and negatively correlated with jump height (r=0.65). For the Division II players, the MTT had large relationships with the 10m sprint and jump (r=0.66). The 505 had large relationships with the 10m sprint (r=0.55) and all the jump variables (r=0.66). Kobal et al. (2021) studied the relationships between linear sprint, curve sprint, COD, and jump performances in elite female soccer players. They reported that jumping ability was significantly correlated with linear sprint (r=0.45-0.55) and curve sprint performance (r=0.56-0.64), but not with COD performance, where only one COD test (r=0.21-0.32) was used.

However, the mentioned studies used one or a small number of tests to determine COD ability and a wide range of participants. In addition, they did not have an elite sample. In this regard, some authors believe that COD has multiple qualities, including more physical and technical aspects where, affected by performance in addition to the production of force (Dos' Santos, McBurnie, Thomas, Comfort, & Jones, 2020).

Therefore, the purpose of this study was to present the physical characteristics of elite female soccer players and to analyze the relationship between jump performance, speed and COD ability, as well as the correlation between these abilities and COD ability. It was hypothesized that the analysis would show a moderate to strong relationship between jump performance, speed and COD ability.

METHODS

Participants

Sixteen elite female soccer players (age: 20.05±2.85; height: 166.47±4.83cm; body weight: 60.52±8.30kg, BMI 21.88±2.86) from a women's club who played the highest rank of the competition took part in the study. Prior to examination, the participants were informed about the protocol both in writing and verbally, about the possible risks and benefits of the study, as well as about the possibility of withdrawing at any time during the study. All the players and their guardians gave written consent for voluntary participation in the testing. The study was approved by the local university (code: 04-921) and followed the ethical standards of The Declaration of Helsinki for the study of humans. Players who were recruited had at least 5 years of experience in playing soccer; had a general training history (more than four times per week) in the previous 12 months; were currently training soccer (more than 7 h per week); and did not have any existing medical conditions that would compromise their participation.

Procedures (Study Design)

All the athletes were informed about the complete procedure. On every occasion, all tests were performed on an open field with a natural, grassy surface of the mentioned club in the morning hours (9am-11am). Prior to the tests, the athletes had a warm-up that included a general and a specific part which lasted 20 minutes. The first part was running

for 10 minutes, then 5 minutes of stretching, and then a specific part in the form of progressive running, change of direction, and plyometrics that lasted 7 minutes. The order of the tests was as follows: (1) the Squat jump (SJ), (2) Countermovement Jump (CMJ), countermovement jump with an arm swing (CMJA), (2) running speed at 30m with passing time at 10m and 20m, (3) the pro agility test (pro), (4) zig-zag test (zig-zag), and (5) 9-6-3-6-3 sprint (9-6-3-6-9).

Measurement

Anthropometry

Height and body weight were measured to the nearest 0.1cm using a Martin anthropometer (GPM in Switzerland), and to the nearest 0.1kg using a calibrated balance beam (Avery Ltd, Model 3306 ABV).

Vertical Jumps (SJ, CMJ, CMJA)

Vertical jumps were assessed by using the squat and countermovement jumps. The squat jump (SJ) consisted of a standing position with knees flexed at 90 degrees, hands on the waist. With no help of the upper limbs, the player should jump and extend the legs, falling in the same place. The players waited 3s in the squat position before each jump. The countermovement jump (CMJ) started in a standing position with hands on the waist, realized with flexion of the legs and simultaneously with the jump, the legs will be extended and fall in the same place. While the CMJA jump procedure was the same as for the previous jump, only the hands were free during all the phases of the maximum jump. For each movement, three trials were executed, with a rest period of 30s between them. The SJ, CMJ, and CMJA were tested with an optical measurement system consisting of a transmitting and receiving bar (Optojump, Microgate, Bolzano, Italy). The outcome extracted in each trial was the jump height (cm). For each measure, the highest jump was taken into consideration for data analysis. The validity and reliability of these tests have been confirmed in research (Glatthorn et al., 2011).

Speed (running 0-30m)

The running speed of the players was determined using the time at 10, 20, and 30m using infrared timing gates, 30m sprint effort with photocell gates (Microgate, Polifemo Radio Light, Bolzano, Italy) placed 0.4m above the ground, with an accuracy of 0.001s. The timer was automatically activated as the participants crossed the first gate at the starting line with split times at 10m and 20m. The players were instructed to run the 30m distance as quickly as possible from a standing start (crouched start positioned 0.5m behind the timing lights). Acceleration was evaluated using the time to cover the first 10m of the 30m test. The participants performed two trials with at least 3 minutes of rest between them. The best performance of the two tests was used for further analysis. The 30m sprint was previously used to estimate linear speed in a study by Nimphius, Callaghan, Spiteri, & Lockie (2016).

COD ability (Pro agility, Zig-zag, 9-6-3-6-9)

Pro Agility Test

The Pro agility or 5-10-5m test measures the ability to change direction laterally to the right and left. A player assumes the starting position, legs spread laterally on the midfield. Each participant had the choice to choose a side for the sprint (right or left) on the first attempt. In the second attempt, the opposite direction was used. The test starts with a player sprinting 5m and touching the line with their foot, turning 180 degrees, and sprinting 10m to the second outside line and touching it with their foot. The test was completed by performing another 180-degree turn and sprinting back over the midline. The validity and reliability of the test were confirmed in research (Mann, Ivey, Mayhew, Schumacher, & Brechue, 2016).

9-6-3-6-9 Sprint (with 180 degrees turns)

The distance the players covered during this test was 21m. The players started after the signal and ran 9m. Touching the line with one foot, they made a turn of 180 degrees to the left or right. The players then ran 3m to the next line, made another 180-degree turn, and ran 6m forward. Then they made another 180-degree turn and ran another 3m forward, before making the last turn and the final 9m to the finish. The validity and reliability of the test were confirmed in research (Sporis, Jukic, Milanovic, & Vucetic, 2010).

Statistical Analysis

All statistical analyses were performed using SPSS v. 20 (IBM Corporation; Armonk, NY, USA). Descriptive statistics were calculated for all the previously mentioned data. Pearson's correlation coefficient was used to determine the correlation between all the tests. The magnitude of the correlations was interpreted using the following criteria: <; 0.1, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; and > 0.9 almost perfect. The level of significance for the correlation analysis was set at $p \leq 0.05$ (Hopkins, Marshall, Batterham, & Hanin, 2009).

RESULTS

Table 1 shows the descriptive data of the physical tests performed by the female soccer players. Table 2 shows Pearson's correlation coefficients, the p value among the jump and speed tests (SJ, CMJ, CMJA, 10m, 20m, 30m) and COD tests (pro agility, zig-zag, 9-6-3-6-9). Moderate significant relationships were shown between the 10m running and pro agility test ($r=0.59$; $p<0.01$), as well as the zig-zag ($r=0.55$; $p<0.01$), and between the 30m and all COD tests (pro agility $r=0.66$; $p<0.01$, zig-zag $r=0.59$; $p<0.01$ and 9-6-3-6-9 $r=0.58$; $p<0.05$). A small correlation ($r=0.49$; $p<0.03$) was noticed between the 10m running test and 9-6-3-6-9 agility test, and also between the CMJA ($r=0.45$; $p<0.05$) and the 9-6-3-6-9 agility test. All significant correlations for the jump performance and COD tests were negative, which indicated a faster time in the particular sprint test related to a superior jump performance. There were no significant relationships between the COD variables and SJ or 20m running speed.

Table 1 Descriptive data of the tested variables

	Mean ± SD
SJ (cm)	24.24 ± 2.60
CMJ (cm)	25.80 ± 2.86
CMJA (cm)	28.95 ± 3.27
10m (s)	1.90 ± 0.27
20m (s)	3.37 ± 0.17
30m (s)	4.71 ± 0.22
Pro agility (s)	5.17 ± 0.18
Zig-zag (s)	5.81 ± 0.30
9-6-3-6-9 (s)	8.36 ± 0.30

Legend: SJ-squat jump, CMJ-countermovement jump, CMJA-countermovement with free arms, 10m-running speed at 10m, 20m-running speed at 20m, 30m-running speed at 30m, 9-6-3-6-9-agility test (9-6-3-6-9)

Table 2 Pearson's correlation coefficients between jumps, speed, and COD

Variables (n=19)		Pro agility test	Zig-Zag test	9-6-3-6-9
10m	r	0.59	0.55	0.49
	p	0.01	0.01	0.03
	Magnitude	Large	Large	Moderate
20m	r	0.30	0.37	0.34
	p	0.20	0.12	0.16
	Magnitude	Small	Moderate	Moderate
30m	r	0.66	0.59	0.58
	p	0.01	0.01	0.01
	Magnitude	Large	Large	Large
CMJ	r	-0.38	-0.25	-0.42
	p	0.10	0.29	0.05
	Magnitude	Moderate	Small	Moderate
CMJA	r	-0.29	-0.24	-0.45
	p	0.21	0.31	0.05
	Magnitude	Small	Small	Moderate
SJ	r	-0.18	-0.12	-0.23
	p	0.46	0.61	0.34
	Magnitude	Small	Small	Small

Legend: SJ-squat jump, CMJ-countermovement jump, CMJA-countermovement jump with free arms, 10m-running speed at 10m, 20m-running speed at 20m; 30m-running speed at 30m, 9-6-3-6-9-agility test (9-6-3-6-9), p-significant value ($p \leq 0.05$), r-Pearson's correlation.

DISCUSSION

The aim of this study was to analyze the relationships between jump performance, speed, and COD performances in elite female soccer players. The main findings indicated that (1) a moderate relationship were noticed between the 30m running speed and all the COD tests (the Pro agility test $r= 0.66$, $p \leq 0.01$; Zig-Zag test $r= 0.59$, $p \leq 0.01$; 9-6-3-6-9 $r= 0.58$, $p \leq 0.01$), also between the 10m running speed and all the COD tests (the Pro agility test $r= 0.59$, $p \leq 0.01$; Zig-Zag test $r= 0.55$, $p \leq 0.01$; 9-6-3-6-9 $r= 0.49$, $p \leq 0.03$); (2) players faster in linear speed displayed greater COD; however, no significant relationship was found between the 20m running speed and the COD tests (the Pro agility test $r= 0.30$, $p \leq$

0.20; Zig-Zag test r= 0.37, p≤ 0.12; 9-6-3-6-9 r= 0.34, p≤ 0.16), the relationship was even close to the mentioned speed tests; (3) only the CMJA was significantly correlated with one COD test (9-6-3-6-9 r= -0.45, p≤ 0.05); however, contrary to the study's hypothesis, there were no significant relationships between the jump tests and pro agility (CMJ r= -0.38, p≤ 0.10; CMJA r= -0.29, p≤ 0.21; SJ r= -0.18, p≤ 0.46) and zig-zag test (CMJ r= -0.25, p≤ 0.29; CMJA r= -0.24, p≤ 0.31; SJ r= -0.12, p≤ 0.61. These results have several implications for the strength and speed of female soccer coaches, which will be discussed below.

There are many actions in soccer that are realized with high intensity, such as jumping, sprinting, and changing direction (Bishop et al., 2021; Gonzalo-Skok et al., 2017). As previously acknowledged, several studies have detailed significant relationships between jump performance and speed with COD (Kobal et al., 2021; Lockie et al., 2018; Pardos-Mainer et al., 2021). Interestingly, the results from our study provided support for some studies (Freitas et al., 2020; Pardos-Mainer et al., 2021), as each jump test is not significantly correlated with the pro agility and zig-zag tests, while we reported only countermovement jump height with free hands to be related to 9-6-3-6-9. However, our findings are inconsistent with previous research reporting the importance of maximum power and reactive power for the COD performance in female athletes (Nimphius et al., 2010; Young, James, & Montgomery, 2002). In this regard, our findings match the results of Pardos-Mainer et al. (2021) and Freitas et al. (2020) who reported that there was no relationship between CMJ and COD. All correlations for the jump performance and COD tests were negative, which indicated a faster time in the particular sprint test related to a superior jump performance. There were no significant relationships between COD variables and the CMJ, SJ or 20m running speed. The power of the lower-body and reactive strength are considered to be the base when defining COD ability (Lockie et al., 2018). To be able to perform an effective direction change, it is necessary to have eccentric strength in order to decelerate the body, which must be followed by concentric force development for reacceleration in the new intended direction (Spiteri et al., 2015). We reported only a relationship between CMJA and 9-6-3-6-9 tests. A possible reason for this result is using hands in both cases. Furthermore, the use of hands would resemble hand coordination in COD, which corresponds to movements patterns in these tests. More precisely, similar manipulation of the hands is performed when executing a jump and when performing a turn during the mentioned agility test (Braz et al., 2017).

As we have already mentioned, the jumping performance is an important component of a player's ability, because it plays a huge role in defense as well as in offense actions during a soccer match (Wing, Turner, & Bishop, 2020). Although several studies (Lockie et al., 2018; Loturco, Pereira, et al., 2020; McFarland, Dawes, Elder, & Lockie, 2016; Vescovi & Mcguigan, 2008) have found strong relationships between jumping performance and COD, that was not the case in our study. There is no relationship between SJ and any COD tests, which supports the study results of Kobal et al. (2021) who also reported no significant relationship between the zig-zag and SJ (r=0.32). This finding could be explained by the differences in the performance which are thought to reflect an effective utilization of the stretch-shortening cycle (Hammami, Gaamouri, Suzuki, Shephard, & Chelly, 2020). It is concluded that the difference in performance may primarily be related to the higher uptake of muscle slack and stimulation increase throughout the countermovement in a CMJ, as well as elastic energy (Gerodimos et al., 2008). Furthermore, one of the possible reasons for this is that each player has different levels of physical abilities and skills that may be linked to the distance used in the sprint tests (Lockie et al., 2014). These results

enhance the complex nature of the connection between tests of physical performance (Raya-González et al., 2020).

Mastering the skill to change direction during sprint is considered to be a very important characteristic in female soccer (Emmonds, Nicholson, Begg, Jones, & Bissas, 2019). The relationship between sprint and agility performance have been also examined by a very few studies (Little & Williams, 2003; Lockie et al., 2018; Loturco et al., 2019). We found a moderate relationship between the 30m sprint and all COD tests (pro agility r=0.66, zig-zag r=0.59, 9-6-3-6-9 r=0.58). Although there was no study with female participants, Sporiš, Milanović, Trajković, & Joksimović (2011) analysed male soccer players and also found moderate correlation between the 30m sprint and zig-zag test (r=0.56). In this regard, Popowczak et al. (2019) reported relationships between the 30m sprint and the COD (r=0.60). In addition, our results, along with the mentioned ones, are not in accordance with Freitas et al. (2020), who did not find a significant relationship (r=0.23) between speed and COD tests. A possible reason for our result is the similar duration of running speed at 30m and the duration of COD tests. In order to reach a greater speed over short periods of time, athletes must be able to effectively accelerate over short distances, which could lead to performing with significant amounts of force to the ground to be able to overcome the total moment of inertia (Loturco et al., 2019). As a result, it is expected that players who showed higher maximum acceleration rates would be more likely to achieve better quality performances in linear sprints up to 30-m.

Brown, Ferrigno, & Santana (2005) have described acceleration as a change in velocity in a unit of time. In other words, it is essential to produce maximum force in a minimum period of time (Haff & Triplett, 2015), which can be seen in soccer - like any other sport (Dalen, Jørgen, Gertjan, Havard, & Ulrik, 2016; Ingebrigtsen, Dalen, Hjelde, Drust, & Wisløff, 2015; Mara, Thompson, Pumpa, & Morgan, 2017). Our study reported a relationship between 10m and all COD tests (pro agility r=0.59, zig-zag r=0.55, 9-6-3-6-9 r=0.49), which are among those reported in the literature to date (r=0.39–0.82). In agreement with the results of the current study, Lockie et al. (2018) reported a positive relationship between the 10m sprint and 505 test, as well as the modified T test, in a group of Collegiate soccer players. In a group of professional male soccer players, Little & Williams (2005) reported a weak but significant correlation between the 10m sprint and zig-zag agility test. Similar to that, Köklü, Alemdaroğlu, Özkan, Koz, & Ersöz (2015) also conducted experiments on male soccer players and found a moderate correlation between the 10m sprint and COD test with angles of 100 degrees, which is also the test that we used in this study. The reason for our results may lie in the fact that each agility test contains a running distance of 10m. The sprint time (10m) of elite female players in this study was faster than that previously reported of elite Australian players (1.91±0.04) and close, but a bit slower than that of elite English players (1.87±0.06). Analyzing the correlation between COD and the linear 30m sprint, the pattern of backward movement performed between 15 and 20m allows us to determine the specific skills needed during a soccer match (Popowczak et al., 2019).

Regarding this, we have not found a relationship between the 20m sprint and any of the COD tests, even if the relationship between the mentioned speed tests was close (r=0.37). The differences between studies, most likely, could reflect the use of different agility tests. Likewise, the total time to complete the COD test does not necessarily represent the player's COD ability (Nimphius et al., 2016). Therefore, a player who has a greater linear speed could still perform well on a COD test, due to their sprinting ability which could disguise any deficiencies in COD ability (Emmonds et al., 2019). Better momentum is usually associated with stronger braking and propulsive forces during sequential decelerations and

accelerations, and longer contact time with the ground in COD drills (Chaalali et al., 2016). Thus, the entry and exit velocities could possibly be affected during successive COD maneuvers while reducing the efficiency of faster athletes to change of direction (Vescovi & Mcguigan, 2008). In this regard, one of the possible reasons might be technical issues, such as biomechanical adjustments. It is known that players need to change their manner of running from forward (deceleration) to backward (re-acceleration) during COD tests, which requires high-level motor abilities that are of crucial importance among all the skills needed for COD (Popowczak et al., 2019).

There are study limitations that should be mentioned. Despite the fact that COD performance can distinguish between playing levels in male soccer players (Suchomel, Nimphius, & Stone, 2016), there is limited research available on the COD ability of female soccer players. As there is limited data available, the contrast between the studies is further limited by the different testing methods used to assess COD ability (505, T-test, pro agility). It would be of interest to investigate other COD tests, as well as the COD deficit, unilateral, and dynamic strength. Dissimilarities in the length of the lower limbs and body asymmetry have not been taken into consideration in this study; however, these might be important to the manner of speed. Furthermore, the relationships between physical qualities and change of direction performance through different turn angles should be considered. According to Nimphius et al. (2018), COD ability could be influenced by the angle of direction change, and this is probably associated with the physical qualities required for optimal performance. Also, future research should include reactive agility, as an important skill besides agility which is the key skill required for soccer success (Andrašić et al., 2021). Comprehending the physical qualities that could mostly influence COD ability improvements over shorter and longer distances could highlight training efficiency (Lockie, Post, & Dawes, 2019). It is of big importance to consider specific movement patterns before making a training program for team sport athletes (Stanković et al., 2021), in particular those that include eccentric exercises, acceleration and deceleration efforts, which can include specific for COD drills.

CONCLUSION

Elite female soccer players with higher maximum acceleration rates and speed tend to perform better in change of direction tests. On the other hand, jump performance does not significantly correlate with COD ability. In practical terms, this means that they need more time to change direction. Future studies should investigate whether more combined training strategies, such as circuit-training sessions involving eccentric exercises, plyometrics, and successive acceleration-deceleration drills, are able to improve COD in elite female soccer players.

PRACTICAL IMPLICATION

There are several practical applications that can be drawn from this study which could be of great benefit for strength and conditioning coaches. The primary finding of this study is that speed and COD are related abilities. Thus, using the load that maximizes linear sprint abilities can improve the COD performance of elite female soccer players. Therefore, both a conditioning coach and a sport scientist can tailor the physical conditioning more

effectively to improve players' performance. Additionally, this supply provides normative data and performance quality for elite female soccer players, so that a conditioning coach can use these particulars to adjudicate standards of physical condition in the preseason and during the season.

REFERENCES

Andrašić, S., Gušić, M., Stanković, M., Mačak, D., Bradić, A., Sporiš, G., & Trajković, N. (2021). Speed, Change of Direction Speed and Reactive Agility in Adolescent Soccer Players: Age Related Differences. *International Journal of Environmental Research and Public Health*, *18*(11), 5883. Multidisciplinary Digital Publishing Institute.

Banda, D. S., Beitzel, M. M., Kammerer, J. D., Salazar, I., & Lockie, R. G. (2019). Lower-body power relationships to linear speed, change-of-direction speed, and high-intensity running performance in DI collegiate women's basketball players. *Journal of human kinetics*, *68*, 223. De Gruyter Open.

Bishop, C., Lake, J., Loturco, I., Papadopoulos, K., Turner, A., & Read, P. (2021). Interlimb asymmetries: The need for an individual approach to data analysis. *The Journal of Strength & Conditioning Research*, *35*(3), 695–701. LWW.

Braz, T. V., Nogueira, J. W., de Assis Cruz, W., Businari, B. G., de Ornelas, F., Brigatto, F. A., Germano, M. D., et al. (2017). Relation between different variables of vertical jumps and sprints in brazilian professional soccer players. *Journal of Exercise Physiology Online*, *20*(1), 33–47. American Society of Exercise Physiologists.

Brown, L. E., Ferrigno, V. A., & Santana, J. C. (2005). Training for Speed. *Agility, and Quickness, Human Kinetics, UK*.

Brughelli, M., Cronin, J., Levin, G., & Chaouachi, A. (2008). Understanding change of direction ability in sport. *Sports medicine*, *38*(12), 1045–1063. Springer.

Chaabene, H., Prieske, O., Negra, Y., & Granacher, U. (2018). Change of direction speed: Toward a strength training approach with accentuated eccentric muscle actions. *Sports Medicine*, *48*(8), 1773–1779. Springer.

Chaalali, A., Rouissi, M., Chtara, M., Owen, A., Bragazzi, N. L., Moalla, W., Chaouachi, A., et al. (2016). Agility training in young elite soccer players: promising results compared to change of direction drills. *Biology of sport*, *33*(4), 345. Institute of Sport.

Chaouachi, A., Manzi, V., Chaalali, A., Wong, D. P., Chamari, K., & Castagna, C. (2012). Determinants analysis of change-of-direction ability in elite soccer players. *The Journal of Strength & Conditioning Research*, *26*(10), 2667–2676. LWW.

Çinarli, F. S., Kafkas, A. Ş., & Kafkas, M. E. (2018). Relationship between linear running and change of direction performances of male soccer players. *Turkish Journal of Sport and Exercise*, *20*(2), 93–99.

Colyer, S. L., Nagahara, R., Takai, Y., & Salo, A. I. T. (2018). How sprinters accelerate beyond the velocity plateau of soccer players: Waveform analysis of ground reaction forces. *Scandinavian journal of medicine & science in sports*, *28*(12), 2527–2535. Wiley Online Library.

Dalen, T., Jørgen, I., Gertjan, E., Havard, H. G., & Ulrik, W. (2016). Player load, acceleration, and deceleration during forty-five competitive matches of elite soccer. *The Journal of Strength & Conditioning Research*, *30*(2), 351–359. LWW.

Datson, N., Drust, B., Weston, M., Jarman, I. H., Lisboa, P. J., & Gregson, W. (2017). Match physical performance of elite female soccer players during international competition. *The Journal of Strength & Conditioning Research*, *31*(9), 2379–2387. LWW.

Dos' Santos, T., McBurnie, A., Thomas, C., Comfort, P., & Jones, P. A. (2020). Biomechanical determinants of the modified and traditional 505 change of direction speed test. *The Journal of Strength & Conditioning Research*, *34*(5), 1285–1296. LWW.

Dos'Santos, T., Thomas, C., Comfort, P., & Jones, P. A. (2018). The effect of angle and velocity on change of direction biomechanics: An angle-velocity trade-off. *Sports Medicine*, *48*(10), 2235–2253. Springer.

Emmonds, S., Nicholson, G., Begg, C., Jones, B., & Bissas, A. (2019). Importance of physical qualities for speed and change of direction ability in elite female soccer players. *The Journal of Strength & Conditioning Research*, *33*(6), 1669–1677. LWW.

Fields, J. B., Esco, M. R., Merrigan, J. J., White, J. B., & Jones, M. T. (2020). Internal Training Load Measures During a Competitive Season in Collegiate Women Lacrosse Athletes. *International Journal of Exercise Science*, *13*(4), 778. Western Kentucky University.

Filter, A., Olivares-Jabalera, J., Santalla, A., Morente-Sánchez, J., Robles-Rodríguez, J., Requena, B., & Loturco,

I. (2020). Curve sprinting in soccer: kinematic and neuromuscular analysis. *International Journal of Sports Medicine*, *41*(11), 744–750. © Georg Thieme Verlag KG.

Freitas, T. T., Jeffreys, I., Reis, V. P., Fernandes, V., Alcaraz, P. E., Pereira, L. A., & Loturco, I. (2020). Multidirectional sprints in soccer: are there connections between linear, curved, and change-of-direction speed performances? *The Journal of Sports Medicine and Physical Fitness*.

Gerodimos, V., Zafeiridis, A., Perkos, S., Dipla, K., Manou, V., & Kellis, S. (2008). The contribution of stretch-shortening cycle and arm-swing to vertical jumping performance in children, adolescents, and adult basketball players. *Pediatric exercise science*, *20*(4), 379–389. Human Kinetics, Inc.

Glatthorn, J. F., Gouge, S., Nussbaumer, S., Stauffacher, S., Impellizzeri, F. M., & Maffiuletti, N. A. (2011). Validity and reliability of optojump photoelectric cells for estimating vertical jump height. *Journal of Strength and Conditioning Research*, *25*(2), 556–560.

Gonzalo-Skok, O., Tous-Fajardo, J., Suarez-Arrones, L., Arjol-Serrano, J. L., Casajús, J. A., & Mendez-Villanueva, A. (2017). Single-leg power output and between-limbs imbalances in team-sport players: Unilateral versus bilateral combined resistance training. *International journal of sports physiology and performance*, *12*(1), 106–114. Human Kinetics, Inc.

Goral, K. (2015). Examination of agility performances of soccer players according to their playing positions. *Sport J*, *51*, 1–11.

Griffin, J., Larsen, B., Horan, S., Keogh, J., Dodd, K., Andreatta, M., & Minahan, C. (2020). Women's football: An examination of factors that influence movement patterns. *The Journal of Strength & Conditioning Research*, *34*(8), 2384–2393. LWW.

Haff, G. G., & Triplett, N. T. (2015). *Essentials of strength training and conditioning 4th edition*. Human kinetics.

Hammami, M., Gaamouri, N., Suzuki, K., Shephard, R. J., & Chelly, M. S. (2020). Effects of upper and lower limb plyometric training program on components of physical performance in young female handball players. *Frontiers in Physiology*, *11*, 1028. Frontiers.

Hammami, R., Granacher, U., Pizzolato, F., Chaouachi, M., & Chtara, M. (2017). Associations between Change of Direction, Balance, Speed, and Muscle Power in Prepubescent Soccer Players. J Athl Enhanc 6: 6. *of*, *6*, 2.

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009, January). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*.

Hovden, J. (2012). Discourses and strategies for the inclusion of women in sport–the case of Norway. *Sport in society*, *15*(3), 287–301. Taylor & Francis.

Ingebrigtsen, J., Dalen, T., Hjelde, G. H., Drust, B., & Wisløff, U. (2015). Acceleration and sprint profiles of a professional elite football team in match play. *European journal of sport science*, *15*(2), 101–110. Taylor & Francis.

Kobal, R., Freitas, T. T., Fílter, A., Requena, B., Barroso, R., Rossetti, M., Jorge, R. M., et al. (2021). Curve Sprint in Elite Female Soccer Players: Relationship with Linear Sprint and Jump Performance. *International Journal of Environmental Research and Public Health*, *18*(5), 2306. Multidisciplinary Digital Publishing Institute.

Köklü, Y., Alemdaroğlu, U., Özkan, A., Koz, M., & Ersöz, G. (2015). The relationship between sprint ability, agility and vertical jump performance in young soccer players. *Science & Sports*, *30*(1), e1–e5. Elsevier.

Little, T., & Williams, A. (2003). *Specificity of acceleration, maximum speed and agility in professional soccer players*. Routledge London, UK:

Little, T., & Williams, A. G. (2005). Specificity of acceleration, maximum speed and agility in professional soccer players. *Journal of strength and conditioning research*, *19*(1), 76–78. National Strength and Conditioning Association/Allen Press.

Lockie, R. G., Callaghan, S. J., Berry, S. P., Cooke, E. R. A., Jordan, C. A., Luczo, T. M., & Jeffriess, M. D. (2014). Relationship between unilateral jumping ability and asymmetry on multidirectional speed in team-sport athletes. *The Journal of Strength & Conditioning Research*, *28*(12), 3557–3566. LWW.

Lockie, R. G., Dawes, J. J., & Callaghan, S. J. (2020). Lower-body power, linear speed, and change-of-direction speed in Division I collegiate women's volleyball players. *Biology of sport*, *37*(4), 423. Institute of Sport.

Lockie, R. G., Dawes, J. J., & Jones, M. T. (2018). Relationships between linear speed and lower-body power with change-of-direction speed in national collegiate athletic association divisions I and II women soccer athletes. *Sports*, *6*(2), 30. Multidisciplinary Digital Publishing Institute.

Lockie, R. G., Post, B. K., & Dawes, J. J. (2019). Physical qualities pertaining to shorter and longer change-of-direction speed test performance in men and women. *Sports*, *7*(2), 45. Multidisciplinary Digital Publishing Institute.

Loturco, I., A. Pereira, L., T. Freitas, T., E. Alcaraz, P., Zanetti, V., Bishop, C., & Jeffreys, I. (2019). Maximum acceleration performance of professional soccer players in linear sprints: Is there a direct connection with change-of-direction ability? *PloS one*, *14*(5), e0216806. Public Library of Science San Francisco, CA USA.

Loturco, I., Jeffreys, I., Abad, C. C. C., Kobal, R., Zanetti, V., Pereira, L. A., & Nimphius, S. (2020). Change-of-direction, speed and jump performance in soccer players: a comparison across different age-categories. *Journal of Sports Sciences*, *38*(11–12), 1279–1285. Taylor & Francis.

Loturco, I., Pereira, L. A., Fílter, A., Olivares-Jabalera, J., Reis, V. P., Fernandes, V., Freitas, T. T., et al. (2020). Curve sprinting in soccer: Relationship with linear sprints and vertical jump performance. *Biology of Sport*, *37*(3), 277. Termedia Publishing House.

Mann, J. B., Ivey, P. A., Mayhew, J. L., Schumacher, R. M., & Brechue, W. F. (2016). Relationship between agility tests and short sprints: Reliability and smallest worthwhile difference in National Collegiate Athletic Association Division-I football players. *The Journal of Strength & Conditioning Research*, *30*(4), 893–900. LWW.

Mara, J. K., Thompson, K. G., Pumpa, K. L., & Morgan, S. (2017). The acceleration and deceleration profiles of elite female soccer players during competitive matches. *Journal of science and medicine in sport*, *20*(9), 867–872. Elsevier.

Marcelino, P. R., Aoki, M. S., Arruda, A. F. S., Freitas, C. G., Mendez-Villanueva, A., & Moreira, A. (2016). Does small-sided-games' court area influence metabolic, perceptual, and physical performance parameters of young elite basketball players? *Biology of sport*, *33*(1), 37. Institute of Sport.

Martínez-Lagunas, V., Niessen, M., & Hartmann, U. (2014). Women's football: Player characteristics and demands of the game. *Journal of Sport and Health Science*, *3*(4), 258–272. Elsevier.

McFarland, I. T., Dawes, J. J., Elder, C. L., & Lockie, R. G. (2016). Relationship of two vertical jumping tests to sprint and change of direction speed among male and female collegiate soccer players. *Sports*, *4*(1), 11. Multidisciplinary Digital Publishing Institute.

Milanović, Z., Sporiš, G., James, N., Trajković, N., Ignjatović, A., Sarmento, H., Trecroci, A., et al. (2017). Physiological Demands, Morphological Characteristics, Physical Abilities and Injuries of Female Soccer Players. *Journal of Human Kinetics*, *60*(1).

Mujika, I., Santisteban, J., Impellizzeri, F. M., & Castagna, C. (2009). Fitness determinants of success in men's and women's football. *Journal of sports sciences*, *27*(2), 107–114. Taylor & Francis.

Nimphius, S., Callaghan, S. J., Spiteri, T., & Lockie, R. G. (2016). Change of direction deficit: A more isolated measure of change of direction performance than total 505 time. *Journal of strength and conditioning research*, *30*(11), 3024–3032. Wolters Kluwer.

Nimphius, S., Mcguigan, M. R., & Newton, R. U. (2010). Relationship between strength, power, speed, and change of direction performance of female softball players. *The Journal of Strength & Conditioning Research*, *24*(4), 885–895. LWW.

Pardos-Mainer, E., Bishop, C., Gonzalo-Skok, O., Nobari, H., Pérez-Gómez, J., & Lozano, D. (2021). Associations between inter-limb asymmetries in jump and change of direction speed tests and physical performance in adolescent female soccer players. *International Journal of Environmental Research and Public Health*, *18*(7), 3474. Multidisciplinary Digital Publishing Institute.

Pereira, L. A., Nimphius, S., Kobal, R., Kitamura, K., Turisco, L. A. L., Orsi, R. C., Abad, C. C. C., et al. (2018). Relationship between change of direction, speed, and power in male and female National Olympic team handball athletes. *The Journal of Strength & Conditioning Research*, *32*(10), 2987–2994. LWW.

Popowczak, M., Rokita, A., Świerzko, K., Szczepan, S., Michalski, R., & Maćkała, K. (2019). Are Linear Speed and Jumping Ability Determinants of Change of Direction Movements in Young Male Soccer Players? *Journal of sports science & medicine*, *18*(1), 109. Dept. of Sports Medicine, Medical Faculty of Uludag University.

Raya-González, J., Bishop, C., Gómez-Piqueras, P., Veiga, S., Viejo-Romero, D., & Navandar, A. (2020). Strength, jumping, and change of direction speed asymmetries are not associated with athletic performance in elite academy soccer players. *Frontiers in psychology*, *11*, 175. Frontiers.

Reilly, T., Bangsbo, J., & Franks, A. (2000). Anthropometric and physiological predispositions for elite soccer. *Journal of sports sciences*, *18*(9), 669–683. Taylor & Francis.

Romero-Moraleda, B., Nedergaard, N. J., Morencos, E., Casamichana, D., Ramirez-Campillo, R., & Vanrenterghem, J. (2021). External and internal loads during the competitive season in professional female soccer players according to their playing position: differences between training and competition. *Research in Sports Medicine*, 1–13. Taylor & Francis.

Di Salvo, V., Baron, R., González-Haro, C., Gormasz, C., Pigozzi, F., & Bachl, N. (2010). Sprinting analysis of elite soccer players during European Champions League and UEFA Cup matches. *Journal of sports sciences*, *28*(14), 1489–1494. Taylor & Francis.

Spiteri, T., Newton, R. U., Binetti, M., Hart, N. H., Sheppard, J. M., & Nimphius, S. (2015). Mechanical determinants of faster change of direction and agility performance in female basketball athletes. *The Journal of Strength & Conditioning Research*, *29*(8), 2205–2214. LWW.

Sporis, G., Jukic, I., Milanovic, L., & Vucetic, V. (2010). Reliability and factorial validity of agility tests for soccer players. *The Journal of Strength & Conditioning Research*, *24*(3), 679–686. LWW.

Sporiš, G., Milanović, Z., Trajković, N., & Joksimović, A. (2011). Correlation between speed, agility and quickness (SAQ) in elite young soccer players. *Acta kinesiologica*, *5*(2), 36–41.

Stanković, M., Gušić, M., Nikolić, S., Barišić, V., Krakan, I., Sporiš, G., Mikulić, I., et al. (2021). 30–15 Intermittent Fitness Test: A Systematic Review of Studies, Examining the VO2max Estimation and Training

Programming. *Applied Sciences*, *11*(24), 11792. Multidisciplinary Digital Publishing Institute.
Strauss, A., Sparks, M., & Pienaar, C. (2019). The use of GPS analysis to quantify the internal and external match demands of semi-elite level female soccer players during a tournament. *Journal of sports science & medicine*, *18*(1), 73. Dept. of Sports Medicine, Medical Faculty of Uludag University.
Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The importance of muscular strength in athletic performance. *Sports medicine*, *46*(10), 1419–1449. Springer.
Trewin, J., Meylan, C., Varley, M. C., & Cronin, J. (2018). The match-to-match variation of match-running in elite female soccer. *Journal of science and medicine in sport*, *21*(2), 196–201. Elsevier.
Vescovi, J. D., & Mcguigan, M. R. (2008). Relationships between sprinting, agility, and jump ability in female athletes. *Journal of sports sciences*, *26*(1), 97–107. Taylor & Francis.
Wing, C. E., Turner, A. N., & Bishop, C. J. (2020). Importance of strength and power on key performance indicators in elite youth soccer. *The Journal of Strength & Conditioning Research*, *34*(7), 2006–2014. LWW.
Young, W. B., James, R., & Montgomery, I. (2002). Is muscle power related to running speed with changes of direction? *Journal of sports medicine and physical fitness*, *42*(3), 282–288. EDIZIONE MINERVA MEDICA.

POVEZANOST PERFORMANSI SKOKA, BRZINE I COD BRZINE ELITNIH FUDBALERKI

Svrha ove studije bila je da se predstavi fizički učinak elitnih fudbalerki i da se analizira povezanost između performansi skoka, brzine i COD brzine. U ovom istraživanju učestvovalo je 16 elitnih fudbalerki (uzrast: 20,05±2,85; visina: 166,47±4,83cm; telesna težina: 60,52±8,30 kg, BMI 21,88±2,86) iz ženskog kluba koji igra najviši rang takmičenja. Sposobnosti skoka, brzine i COD svake igračice određivane su korišćenjem: (1) skoka iz čučnja (SJ), (2) vertikalnog skoka (CMJ), vertikalnog skoka sa zamahom rukama (CMJA), (2) brzine trčanja na 30- m sa prolaznim vremenom na 10m i 20m, (3) pro agiliti test (pro), (4) cik-cak test (cik-cak), (5) 9-6-3-6-3 sprint (9-6 -3-6-9). Rezultati Pirsonove korelacije ukazali su na umereno značajnu povezanost između brzine trčanja na 10m i pro agiliti testa (r=0,59; p<0,01), kao i cik-cak testa (r=0,55; p<0,01), kao i između 30m i svi COD testovi (pro agilnost r=0,66; p<0,01, cik-cak r=0,59; p<0,01 i 9-6-3-6-9 r=0,58; p<0,05). Uočena je mala korelacija (r=0,49; p<0,03) između testa trčanja na 10 metara i testa agilnosti 9-6-3-6-9, kao i između CMJA (r=0,45; p<0,05) i 9- 6-3-6-9 test agilnosti. Nalazi ove studije ukazali su na značajnu korelaciju između brzine i svih COD testova, dodatno između CMJA i 9-6-3-6-9 COD testa. Stoga, elitne fudbalerke sa većim maksimalnim ubrzanjem, kao i brzinom, imaju tendenciju da bolje rade testove promene smera. S druge strane, performanse skoka nemaju značajnu korelaciju sa sposobnošću COD-a.

Ključne reči: *timski sport, agilnost, terensko testiranje, eksplozivna snaga*

FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 20, No 1, 2022, pp. 61 - 72
https://doi.org/10.22190/FUPES220218006V

Research article

THE VALIDITY AND RELIABILITY OF THE REACTION TIME AND BASKETBALL DEFENSIVE SLIDE SPEED TEST

UDC 796.015.868-055.2
796.323-055.2

Igor Vučković[1], Aleksandar Gadžić[2], Saša Marković[1], Željko Sekulić[1]

[1]Faculty of Physical Education and Sport, University of Banja Luka, Bosnia and Herzegovina
[2]Faculty of Physical Education and Sports Management, Singidunum University, Belgrade, Serbia

Abstract. *The aim of the present study was to examine the content validity and reliability of the newly developed Reaction Time and Defensive Slide Test (RTADST). Thirty-six female basketball players were recruited from three professional State Basketball league of Bosnia and Herzegovina clubs (age: 18.81 ± 2.58 years) who completed three separate trials of the RTADST with each trial consisting of fast shuffling movements left and right. Each athlete performed the test 3 times in one day, and repeated testing was conducted the following day at evening basketball sessions. The RTADST relative reliability was evaluated by Cronbach's alpha and ICC. Cronbach's alpha coefficient was 0.81 which indicates good reliability. When recommendations from Bucheit et al. (2011) were taken into account, the value of ICC <0.69 indicated poor reliability. Absolute reliability of RTADST was assessed by CV, and its value was 5.3%, which is somewhat above the 5%, or the limit of acceptable reliability. Parameters of relative and absolute reliability after the exclusion of the first trial (familiarization with the test task), were more acceptable. Cronbach's alpha coefficient was 0.90 and ICC = 0.82 compared to the one from all three trials. Considering absolute reliability, it could be concluded that the test is reliable since the CV value is below 5% (3.9%). Reliability between two days was assessed by ICC, and its value was 0.74, which confirms good reliability. Finally, the RTADST can be considered as a valid test that discriminates female basketball perimeter players and post players in reaction time and basketball defensive slide speed, while conditioning programs for the development of these abilities need to be carried out with a tool such is RTADST for the initial and final evaluation of these abilities.*

Key words: *Assessment of agility, nonplanned agility, female basketball players.*

Received February 18, 2022 / Accepted April 23, 2022
Corresponding author: Igor Vučković
Faculty of Physical Education and Sport, University of Banja Luka, Bosnia and Herzegovina
E-mail: igor.vuckovic@ffvs.unibl.org

INTRODUCTION

Modern basketball can be described as an open skill-sport characterized by different highly intermittent activities, with sustained contributions from both anaerobic and aerobic metabolic pathways. Performance analysis in basketball has primarily been quantified through measurement of players' physiological responses (Montgomery, Pyne, & Minahan, 2010; Narazaki, Berg, Stergiou, & Chen, 2009; Rodriguez-Alonso, Fernandez-Garcia, Perez-Landaluce, & Terrados, 2003). Modern basketball requires a well-developed physical aerobic and anaerobic fitness, especially at the elite level (Ben Abdelkrim, Chaouachi, Chamari, Chtara, & Castagna, 2010). All these components of the game of basketball differ significantly across varying competition levels, as previous research examining the differences in the activity demands in basketball revealed that elite players performed significantly more total movement changes, and experienced greater activity workloads while jogging and running (Scanlan, Dascombe, & Reaburn, 2011).

Understanding the demands of modern basketball as a competitive sport where the opposing sides are under constant alternations between offensive and defensive plays is essential when designing training programs. Findings of an earlier study of the quality of standard situational efficiency indicators in basketball identified six inter-independent latent dimensions with three dimensions that refer to defensive elements: defensive aggressiveness on the player in possession of the ball, basic defensive efficiency and defensive/offensive back line efficiency (Sporiš, Šango, Vučetić, & Mašina, 2006). There are several strategic decisions that constrain behavior during basketball games and one of the most important is the level of defensive pressure due to its strong influence on game pace and, consequently, on teams' performance and success (Leite, et al., 2014).

One of the most important components of the defensive game in basketball is the defensive slide (lateral agility). In a time-motion analysis, authors found that 31% of the playing time of male basketball players was spent in shuffling movements, of which 20% was spent in high-intensity shuffling movements (Mcinnes, Carlson, Jones, & Mckenna, 1995). The basketball defensive slide is not used only when playing defense on the dribbler, but in activities such as "help and recover", "deny"- defense, etc. From the available physiological and time–motion evidence, it can be suggested that high-intensity shuffling movements are very important in playing man-to-man defense in both situations, that is, guarding the offensive player with and without a ball (Morrison et al., 2022). The effective lateral cutting maneuvers from sliding can be performed if players are able to decelerate and accelerate their body's center of mass quickly (Krause, Meyer, D., & Meyer, J., 2008). During the game, basketball players must perform numerous lateral movements in both directions, as well as many cutting motions in all directions without the dominant leg for lateral cutting maneuvers (Shimokochi, Ide, Kokubu, & Nakaoji, 2013). Same authors indicate that lowering the body's center of mass followed by a powerful and fast hip extension before foot contact may be important for the efficiency of lateral cutting maneuvers from sliding. Roozen (2005) claims that improvement of the hip abductor strength is important for performing efficient lateral motions. The reaction time, as a second condition of a qualitative defense man-to-man, is defined as the time to initiate an athlete's body response after the presentation of a sensory stimulus (Sekulić et al., 2017). In the last 15 years, a number of authors understood the importance of perceptive components and decision-making components when assessing an athlete's agility (Farrow, Young, & Bruce, 2005; Henry, Dawson, Lay, & Young, 2011; Paul, Gabbett, & Nassis, 2016). Agility in

basketball is definitely an important quality. A change of direction (COD) is performed as a reaction to unpredictable visual stimuli (e.g., opponent, teammate, and ball) (Sekulic, Krolo, Spasic, Uljevic, & Peric, 2014). Perceptual and decision-making components of agility are trainable (Serpell, Young, & Ford, 2011).

The existing tests of planned agility (i.e., closed-skill agility, COD speed) and non-planned agility (i.e., open-skill agility, reactive agility) include forward-backward-sideways running, which is basketball-specific agility. However, information about the connections between sprinting, change of direction speed (CODS), and reactive agility remains uncertain. Furthermore, it is not quite clear whether the fastest player at 5m, 10m or 20m forward-backward running is the fastest one in a lateral movement – the defensive slide.

Scientific literature on nonplanned agility in women's basketball is limited (Conte et al., 2015). Research results from elite female Polish junior players suggest that the most important factor describing game effectiveness included speed, power, anaerobic zone training volume, defensive efficiency (Mikolajec, Kubaszczyk, & Waskiewicz, 2005). Furthermore, the same authors reported a significant influence of conditioning on a player's defensive efficiency. Information on movement patterns in women's basketball is limited. Australian female players (n=12) were observed to spend 4±1% of live time shuffling (Scanlan, Dascombe, Reaburn, & Dalbo, 2012). Another study revealed that in female basketball there are more shuffling movements than running or jumping movements (Matthew & Delextrat, 2009).

Agility tests are considered a reliable and valid method of assessing the perceptual and physical components of agility in contemporary research (Paul, Gabbet, & Nassis, 2016). The lateral reactive agility of female basketball players is not significantly correlated to their speed (r=.160 in the 15m sprint from a flying start; r=.415 in the 15m sprint from a standing start) (Čoh et al., 2018).

Recently, the most frequently applied test for non-planned agility is the Y-shaped drill, where athletes receive a stimulus that directs them left or right at an angle of 45°. The results from the study of correlations between the 10-m sprint and Y-shaped agility test under planned and reactive conditions with cuts to the left and right in semiprofessional and amateur basketball players were mixed considering that out of 6 identified correlations, significance (p=.05) was noted in three (Lockie, Jeffriess, McGann, Callaghan, & Schultz, 2014). Previously, Green, Blake, & Caulfield (2011) reported the intraclass correlation coefficient analysis of test–retest Y-shaped drills was r=0.88, and the standard error measure was 0.09. In Oliver & Meyers' research (2009) the reliability Y-shaped drill's data sets was high, with a coefficient of variation of approximately 3%. Another study assessed the nonplanned test (Y-shaped drill) on the sample of female basketball players and intraclass correlation coefficient (ICC) value was 0.86 for tests time using light (Sekulic et al., 2014). The ICC of the nonplanned test in the left and right side for male basketball players were 0.81 and 0.88 (Sekulic et al., 2017). Agility tests definitely contribute the information with respect to the interaction of perceptual-cognitive capacity in conjunction with physical performance (Nimphius, Callaghan, Bezodis, & Lockie, 2018).

Before commencing any program for the improvement of reaction time and defensive slide speed, a coach should know the initial status of his/her players. Consequently, it is very important for a coach to gather precise and reliable data about reaction time and the defensive slide speed abilities of his/her players.

In the specter of the basketball tests, to the authors' knowledge, there is no test that evaluates both the reaction time and basketball defensive slide speed. Therefore, the authors of the present study devised a test that assess these two intertwined abilities and

named it the Reaction Time and Defensive Slide Test (RTADST). Given this, the aim of this study was to assess the validity and reliability of the newly devised test in female basketball players. The authors hypothesized that the RTADST will have acceptable validity and reliability, and practical use when designing conditioning programs for female basketball players.

METHODS

The Experimental Approach to the Problem

The majority of the known and standardized agility tests estimate the ability of the combined movement of players, like forward-backward, left-right, etc. (Horníková & Zemková, 2022). In the most cases those are preplanned tests. To the best of our knowledge, there is no nonplanned test that assesses the reaction time in interaction with the defensive slide. Due to the importance of these two abilities for the defense quality of female basketball players, the Reaction Time and Defensive Slide Test (RTADST) was developed using the Witty SEM devise (Microgate 2015, Italy). Witty SEM was originally designed as a devise for optimal planning and management of specific training for reactivity, agility, and motor-cognitive abilities. Supplementary video material is available at https://youtu.be/fciRufgH1HI.

The participants

Thirty-six female basketball players were recruited from three professional State Basketball league of Bosnia and Herzegovina clubs. Their demographic characteristics are shown in Table 1.

Table 1 Descriptive statistics of the basic anthropometric parameters of the participants

n	Age (years)	Weight (kg)	Height (cm)	BMI	Fat (%)
36	18.81 ± 2.58	70.11 ± 7.72	180.03 ± 6.62	21.63 ± 1.98	20.98 ± 4.57

The number of perimeter players was 22 (weight: 67.43 kg ± 6.36; height: 176.55 cm ± 5.28; BMI = 21.61 ± 1.73; fat percentage = 20.56% ± 5.08). The number of post players was 14 (weight: 74.31 kg ± 8.02; height: 185.50 cm ± 4.49; BMI = 21.66 ± 2.40; fat percentage = 21.64% ± 3.72). The post players were significantly higher (.000) and heavier (.007), while BMI (.940) and fat percentage (.501) showed no differences. The average number of training hours per week was 10.5 with one official game. All players voluntarily participated in this study. The parents of underage basketball players signed consent for their child. All of the participants were healthy and had no injuries at the time of testing.

Procedure

For the RTADST, a course is arranged in rectangular shape with 4 Witty SEM sensors mounted on tripods in each corner of the rectangle. The height of the sensor is set at 120 cm. The distance between the sensors is: the longer rectangle side = 3.5m, the shorter rectangle side = 1.5m (Figure 1). The start line is inside the rectangle and it is 1.5m from the shorter rectangle side. The angle between the longer side of the rectangle and diagonal is ~ 23°.

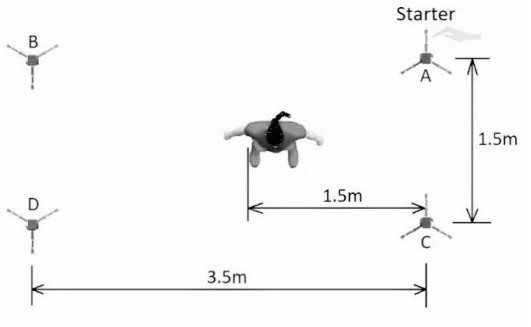

Fig. 1 Distance between the sensors

Fig. 2 Starting position

The athletes were tested just before the end of the preparatory period for the 2019/2020 season. Before the testing, the participants received instructions and a demonstration of correct movement in a defensive stance (without jumping or feet crossing). The starting position, with a straight back, flexed legs, feet slightly divergent and with active hands up is shown in Figure 2. After the instructions, all the athletes participated in 15 minutes of a basketball-specific warm-up: running in pairs or threes with a ball routine for 10 minutes (i.e., criss-cross), a dynamic warm-up, and dynamic stretching for 5 minutes. After that, 4 players were instructed to move to the testing court and the rest of the players continued with light basketball activities that were previously agreed on with their coach. Testing sessions were conducted on a hardwood court. Each test was relatively short in duration (~7-8 seconds), and athletes who were waiting for their turn did not cool down. The test was performed in consecutive order: first athlete, second, third, fourth, with 3 trials each. Consequently, each athlete had enough time to recover (work to rest ratio = 1:3). When one athlete was performing the test, the others were behind the screen in order to prevent their memorization of the order in which the LEDs were lit. When the first four athletes completed the test, they were replaced with another four from the basketball training. It took about 30 minutes to complete the testing of 12 athletes (one team). Testing sessions were conducted in two consecutive days during evening practice. Each athlete performed the test 3 times in one training session, and repeated testing was conducted the following day. The time was measured in intervals of 0.01 second.

The athlete is positioned in the middle of the rectangle with her right foot next to the start line. On the command “ready”, the athlete assumes a defensive stance. As soon as the athlete assumes the correct defensive stance, the tester who is behind and to the left of the athlete activates the photocell beam. Automatically, time measuring and photocell B is activated (LEDs on). The athlete has to perform defensive slides from one photocell to another one in order to deactivate it (LEDs off). As soon as a photocell is deactivated, another one is activated and the athlete needs to move towards it. The scenario of LEDs lighting was: B-C-D-A-B-C. The timer stopped automatically when the last photocell was deactivated, and the Witty SEM device recorded all 6 sequence times, as well as the total time.

Statistical analyses

The statistical analyses were performed using statistical program SPSS (v. 20.0; IBM, Armonk, NY, USA). The normality was assessed by the Kolmogorov-Smirnov test. The

mean values and standard deviations were reported for all the variables (M±SD) at a 90% confidence interval (90% CI). To evaluate measurement validity, an independent t-test was performed to compare the scores between perimeter and post female basketball players. The differences between three trials of agility tests and the assessment of the learning effect were identified using a repeated measures ANOVA with Bonferroni's post hoc comparisons. The magnitude of the differences obtained was interpreted by Cohen's effect size (ES). Effect sizes (*d*) were calculated based on the modified qualitative descriptors in the following classifications: trivial = <0.19; small = 0.20-0.59; medium = 0.60-1.19; large = 1.20-1.99; very large = >2.0 (Hopkins, Marshall, Batterham, & Hanin, 2009). Between-trial reliability of the RTADST was assessed by determining the relative reliability indicated by the intraclass correlation coefficient (ICC) and with Cronbach's alpha coefficient (α). ICC was assessed using the following criteria: trivial = <0.10; small = 0.11-0.30; moderate = 0.31-0.50; large = 0.51-0.70; very large = 0.71-0.90; nearly perfect >0.90; perfect =1 (Hopkins, Marshall, Batterham, & Hanin, 2009). Cronbach's alpha coefficient was interpreted as follows: unacceptable = <0.5; poor = 0.5-0.6; questionable = 0.6-0.7; acceptable = 0.7-0.8; good = 0.8-0.9; excellent = >0.9. The absolute reliability of the agility test was indicated by the coefficient of variation (CV). The following criteria were used to assess the reliability of the test: ICC>0.69 and CV<5% (Buchheit, Lefebvre, Laursen, & Ahmaidi, 2011). Statistical significance was set at $p \leq 0.05$.

RESULTS

Construct validity of RTADST was assessed based on the comparison of the results between perimeter players and post players. The best result of three trials are presented in Table 2.

Table 2 A comparison of the scores between perimeter and post female basketball players

	n	M±SD	t	Sig.	Mean Difference (90%CI)	Cohen's *d*
perpls	22	7.18±0.27	-4.07	0.01	-0.32 (-0.45;-0.18)	1.49
pospls	14	7.50±0.13				

perpls = perimeter players; pospls = post players; n = number of participants;
M = mean; SD = standard deviation; Sig. = level of significance; CI = confidence interval

Perimeter players had better results than post players on the agility test. With regard to the significant, large ($p = 0.01$, $d = 1.49$) difference in the RTADST score between the two group of players, the test can be considered a valid measuring tool due to its ability to discriminate between the players that play in diverse playing positions which demand different levels of agility.

Table 3 Differences between the three trials of RTADST

	M±SD	Wilks' Lambda	*p*	Cohen's *d*	Post-hoc tests	Mean difference (95%CI)	Sig.
trial 1	7.80±0.47				trial 1-trial 2	0.31 (0.16;0.46)	<0.01*
trial 2	7.49±0.28	0.36	<0.01*	0.64	trial 1-trial 3	0.48 (0.31;0.64)	<0.01*
trial 3	7.32±0.28				trial 2-trial 3	0.17 (0.10;0.24)	<0.01*

M = mean; SD = standard deviation; p = level of significance; CI = confidence interval,
Sig. = level of significance; * indicates statistical significance

The results of three consecutive trials of RTADST showed the presence of a learning effect since performance was better in each following trial (Table 3). The results of the repeated measures ANOVA confirm that (Wilks Lambda = 0.36, p <0.01*). Cohen's *d* difference was moderate. The post-hoc tests showed significant differences in all three trials.

Table 4 Relative and absolute reliability of RTADST within one day (*3 measurements on the first day*) and the indicator of relative reliability between the two testings

	reliability within the day					reliability between two days	
	RTADST score	relative reliability			absolute reliability		
	M±SD	α	ICC (95%CI)	*p*	CV (%)	ICC (95%CI)	*p*
trial 1 trial 2 trial 3	7.80±0.47 7.49±0.28 7.32±0.28	0.81	0.59 (0.41;0.75)	<0.01*	5.3	0.61 (0.35;0.78)	<0.01*

M = mean; SD = standard deviation, α = Cronbach's alpha, ICC = intraclass correlation coefficient, CV = coefficient of variation; p = level of significance; * indicates statistical significance

The reliability of the RTADST was assessed with measures of absolute and relative reliability. Three consecutive trials of RTADST for female basketball players were evaluated. Relative reliability was evaluated by Cronbach's alpha and ICC. Cronbach's alpha coefficient was 0.81, which indicates good reliability. Based on the recommendations of Hopkins et al. (2009), an ICC value of 0.59 indicates a large correlation. However, when recommendations from Bucheit et al. (2011) are taken into account, the value of ICC <0.69 indicates poor reliability. ICC was statistically significant at the 0.01 level. The absolute reliability of the RTADST was assessed by CV, and its value was 5.3%, which is somewhat above the 5%, or the limit of acceptable reliability (Bucheit et al., 2011). RTADST reliability between the two sessions within two days was assessed by ICC. ICC was 0.61, which again suggests poor reliability.

Table 5 Relative and absolute reliability of RTADST for female basketball players within one day (two testings on the first day, excluding the first testing) and relative reliability between the two days of testing

	reliability within one day (day 1)					reliability between two days (day 1 and day 2)			
	RTADST score	relative reliability			absolute reliability				
	M±SD	α	ICC (95%CI)	p	CV (%)		M±SD	ICC (95%CI)	p
trial 2 (day 1) trial 3 (day 1)	7.49±0.28 7.32±0.28	0.9	0.82 (0.68;0.90)	<0.01*	3.9	trial 2 (day 2) trial 2 (day 2)	6.99 6.93	0.74 (0.54;0.86)	<0.01*

M = mean; SD = standard deviation; α = Cronbach's alpha; ICC = intraclass correlation coefficient; CV = coefficient of variation; p = level of statistical significance; * indicates statistical significance

Parameters of relative and absolute reliability *after the exclusion of the first trial*, which was the familiarization with the test task, are shown in Table 5. The indicators of relative reliability were higher compared to those when all three trials were included in the analysis.

Cronbach's alpha coefficient was 0.90, indicating excellent reliability of the test. ICC was significantly higher compared to the one from all three trials. Its value was 0.82 which suggests acceptable reliability. Considering absolute reliability, it could be concluded that the test is reliable since the CV value is below 5% (3.9%). Reliability between two days was assessed by ICC, and its value was 0.74, which confirms good reliability.

DISCUSSION

The reaction time and basketball defensive slide speed are two interrelated and very important aspects of defensive play. Since there is no test that evaluates these two abilities of female basketball players, we developed the Reaction Time and Basketball Defensive Slide Speed Test (RTADST). Accordingly, this study aimed to investigate the validity and reliability of this basketball-specific test (RTADST) in order to evaluate nonplanned agility performances of female basketball players. Test validity was evaluated based on the differences between the perimeter and post players in achieved times (scores). Perimeter players yielded significantly better times (Cohen's d = 1.49; large difference, Table 1), hence the test can be considered valid. Also, the newly developed nonplanned agility test (RTADST) is found to be a reliable measuring tool. If the scores from the first trial could be treated as a familiarization of female basketball players with the test task, the indicators of reliability (Table 4) would be acceptable. In that case, Cronbach's alpha coefficient was 0.90, ICC = 0.82, and CV = 3.9%, which confirms the reliability of the RTADST. ICC reliability between two days was 0.74, which indicates good reliability. All obtained indicators suggest that RTADST fulfills the criterions of validity and reliability, with the notion that female basketball players should perform the first trial as a familiarization, while the second trial counts as a score of the RTADST. In regard to that, progression of scoring from the first to the third trial (trial 1 mean = 7.80; trial 2 mean = 7.49; trial 3 mean = 7.32, Table 3) probably depended more on the "adaptation to the task" than on strengthening of the active muscles while performing the defensive slides (mm. adductors and abductors, hip internal and external rotators). In accordance with the claim made by G. Del Rossi, A. Malaguti, and S. Del Rossi (2014), we assumed that the improved reaction times and basketball defensive slide speed in each subsequent test session were likely the result of visual feedback derived from completing earlier test trials.

Our hypothesis that the RTADST will possess acceptable validity and reliability has been confirmed. For unknown reasons there is an apparent lack of developed nonplanned agility tests for women or even smaller number of studies that investigated lateral movements. The most frequently used nonplanned agility test is the Y-shaped drill test, as are its modifications. That test does not include lateral movements. In a study on female basketball players (21 college-aged female athletes; Sekulić et al., 2014), it has been suggested that the shorter version of a Stop'n'go Reactive-Agility Test (a modified Y-shaped drill test - 3 unpredictable changes of direction vs. 5) is more suitable for women because it better discriminates more agile from less agile athletes. The reliability analyses suggested a high consistency for the applied tests (CA = 0.89, CV = 0.04, ICC = 0.86). McCormick (2014) confirmed the reliability and validity of Edgren's popular lateral side-step test. The study assessed 4 different lateral shuffle tests which combined different distances and durations on a sample of male basketball players. All of the tests had very good internal consistency (Cα>0.89), and test-retest reliability (ICC>0.89). However, lateral

movement in Edgren's test is not the same as in the basketball defensive slide, but much different (hopping instead of sliding). Furthermore, this test does not include a perceptual-cognitive component. Farrow, Young, and Bruce (2005) developed a test for the measurement of nonplanned agility for netball. Their test covered lateral movements (hopping instead of sliding) and forward running. A post-hoc analysis showed that high and moderately skilled groups were faster than the lesser skilled group. Intra-class correlations of r> 0.80 indicated acceptable reliability. An original test for the evaluation of agility named the "Successive Choice Reaction Test" was developed by Uchida, Demura, Nagayama and Kitabayashi (2013). On a sample of 15 university students majoring in sports, every tempo test (1.3, 1.5, and 2.0 seconds) was also very reliable (ICC = 0.77–0.93). It is unclear whether the stimulus tempo used in this study is valid or not when using top players majoring in open skill sports as participants, or members of the general public with inferior physical fitness. Results of a study conducted by Spasic, Krolo, Zenic, Delextrat and Sekulic (2015) showed that the reliability of a newly-developed handball-specific reactive-agility test is high (ICC = 0.90, CV = 2.4%). The test included forward running, lateral shuffling and backward running. However, handball lateral shuffling is not the same as basketball sliding, i.e. basketball sliding is physically much different. Loureiro and Freitas (2016) constructed the Nonplanned Agility Test for Badminton Players. The ANOVA test for construct validity revealed that expert players performed the BADCAMP test in a shorter time than nonexpert ones ($p < .001$). The authors used log10 transformations of the real data for test–retest reliability, and the ICC was very high (ICC = .93, 95% CI .82– .97). Furthermore, a paired t-test revealed no difference between the performance on the test and retest ($p = .07$). Veale, Pearce, and Carlson (2010) tested the reliability and construct validity of a novel reactive agility test (RAT) on a sample of elite junior Australian Football players. More importantly, when testing the same population on two occasions separated by 1 week, the results of the RAT showed no significant difference ($p = 0.22$) and good reliability ($r = 0.91$) between the test results, indicating the absence of the learning effect through "test practice". On a population of 15 male and 15 female sport science students, Spiteri, Cochrane, and Nimphius (2013) evaluated test-retest reliability of the response times for the *simple* and *complex* reaction time (RT), movement time (MT), and total movement time (TMT) (ICC = 0.71-0.95; CV = 1.42-5.04). Their tests included leg movements, and both tests were reliable to determine lower body RTs during both conditions (simple and complex). MT and TMT during the Complex Reaction Time test were significantly different, suggesting that MT could be the discriminating factor between conditions, and also genders. The results of Sekulic et al. (2017) indicated that male basketball guards were more successful than centers and forwards in nonplanned agility tests executed on (both) the nondominant and dominant side. Intrasession reliability for a nonplanned agility test on (both) the nondominant and dominant side was high ($ICC_{domside}$=0.86, CV=5.2%; $ICC_{nondomside}$=0.85, CV=5%). Also, the intersession reliability of these tests was high ($ICC_{domside}$=0.88, CV=5%; $ICC_{nondomside}$=0.81, CV=5.4%). In our study, performances of the dominant and nondominant side were not the object of study, since the RTADST was designed to evaluate consecutive movements on the left (3) and right (3) side of female basketball players. An independent samples t-test showed that there are no significant differences in the performance scores on the left and right side (p=.413). A probable explanation for these findings lies in fact that working muscles (mm. adductors & abductors, hip internal & external rotators) in defensive slides (in both directions) were equally active during the training sessions. Zouhal et al. (2018) indicated that reaction time and movement time significantly differ in the dominant vs. nondominant side in soccer players. There are no sliding movements in football and this comparison might be

unsuitable. Langley and Chetlin (2017) modified a 3-Cone Test (3CT) for testing agility and conducted a study on forty male students enrolled in classes in the Department of Physical Education. A modification of the 3-Cone that includes reaction and the choice of a cut to the left (3CTAL) or right (3CTAR), showed good reliability. Intra-class correlation coefficients (ICC) indicated a moderate to high reliability: for 3CTAR, ICC was 0.85 and CI was 0.74-0.92. For 3CTAL, ICC was 0.79 and CI was 0.64-0.88. According to the authors, the main limitation of the study was a lack of motivation among the sample of participants, and that highly motivated athletes should be considered instead.

The findings support the use of the RTADST in practice; however our study has some limitations. Due to the lack of tests for female basketball players, we focused strictly on that sample. However, future research should analyze the validity and reliability of RTADST in male basketball players. Second, many basketball teams do not have access to the equipment (Witty SEM) necessary to perform this type of assessment. And third, the somewhat weaker reliability of the RTADST, compared to the planned agility tests, is expected congruently with previous studies (Sattler et al., 2016; Sekulic, Krolo, Spasic, Uljevic, & Peric, 2014; Spasic, Krolo, Zenic, Delextrat, & Sekulic, 2015). Performances of nonplanned agility include perceptive and reactive components (Sattler et al., 2016; Sekulic, Krolo, Spasic, Uljevic, & Peric, 2014). They are a natural source of error, potential causes of measurement error, and consequently, factors that can affect reliability (Sattler et al., 2016). However, this does not mean that the design of new nonplanned agility tests should be abandoned.

CONCLUSION

The RTADST is a valid test that discriminates female basketball perimeter players and post players in reaction time and basketball defensive slide speed. Also, the RTADST showed acceptable relative and absolute reliability across multiple trials in professional female basketball players. Analyses have shown that testing should be performed 2 times, and the better result counted as the score. When performing the RTADST with a team, the coach should separately evaluate the results of perimeter players, and post players. If a coach wants to carry out a program of reaction time and defensive slide speed development, it ought to be done with a tool such is the RTADST for the initial and final evaluation of these abilities. Normally, between the two tests, a program should be implemented in order to develop basketball specific agility.

Acknowledgment. *The authors specially thank to the athletes and their coaches for participating in this study.*

REFERENCES

Ben Abdelkrim, N., Chaouachi, A., Chamari, K., Chtara, M., & Castagna, C. (2010). Positional Role and Competitive-Level Differences in Elite-Level Men's Basketball Players. *Journal of Strength and Conditioning Research,* 24(5), 1346–1355.

Buchheit, M., Lefebvre, B., Laursen, P. B., & Ahmaidi, S. (2011). Reliability, usefulness, and validity of the 30–15 intermittent ice test in young elite ice hockey players. *Journal of Strength & Conditioning Research,* 25(5), 1457–1464.

Conte, D., Favero, T., Lupo, C., Francioni, F., Capranica, L., & Tessitore, A. (2015). Time-Motion Analysis of Italian Elite Women's Basketball Games: Individual and Team Analyses. *Journal of Strength and Conditioning Research,* 29(1), 144–150.

Čoh, M., Vodičar, J., Žvan, M., Šimenko, J., Stodolka, J., Rauter, S., & Maćkala, K. (2018). Are Change-of-Direction Speed and Reactive Agility Independent Skills Even When Using the Same Movement Pattern? *Journal of Strength and Conditioning Research,* 32(7), 1929–1936.

Del Rossi, G., Malaguti, A., Del Rossi, S. (2014). Practice Effects Associated With Repeated Assessment of a Clinical Test of Reaction Time. *Journal of Athletic Training,* 49(3), 356–359.

Farrow, D., Young, W., & Bruce, L. (2005). The development of a test of reactive agility for netball: A new methodology. *Journal of Science and Medicine in Sport,* 8(1), 52–60.

Green, B., Blake, C., & Caulfield, B. (2011). A Valid Field Test Protocol of Linear Speed and Agility in Rugby Union. *Journal of Strength and Conditioning Research,* 25(5), 1256–1262.

Henry, G., Dawson, B., Lay, B., & Young, W. (2011). Validity of a Reactive Agility Test for Australian football. *International Journal of Sports Physiology and Performance,* 6(4), 534–545.

Hopkins, W., Marshall, S., Batterham, A., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine Science in Sports Exercise,* 41(1), 3–13.

Horníková H, Zemková E. (2022). Determinants of Y-Shaped Agility Test in Basketball Players. *Applied Sciences*. 12(4), 1865. https://doi.org/10.3390/app12041865

Krause, J.V., Meyer, D., & Meyer, J. (2008). *Basketball Skills & Drills*. Champaign, IL: Human Kinetics.

Leite, N.M., Leser, R., Gonçalves, B., Calleja-Gonzalez, J., Baca, A., & Sampaio, J. (2014). Effect of Defensive Pressure on Movement Behaviour During an Under-18 Basketball Game. *International Journal of Sports Medicine, 35*(9), 743-748.

Lockie, R., Jeffriess, M., McGann, T., Callaghan, S., & Schultz, A. (2014). Planned and Reactive Agility Performance in Semiprofessional and Amateur Basketball Players. *International Journal of Sports Physiology and Performance, 9*(5), 766–771.

Loureiro, L. D. B. Jr., & Freitas, P. B. (2016). Development of an Agility Test for badminton players and Assessment of Its Validity and Test-Retest Reliability. *International Journal of Sports Physiology, 11*(3), 305-310.

Matthew, D., & Delextrat, A. (2009). Heart rate, blood lactate concentration, and time–motion analysis of female basketball players during competition. Journal of Sports Sciences, 27(8), 813-821.

McInnes, S.E., Carlson, J.S., Jones, C.J., & Mckenna, M.J. (1995). The physiological load imposed on basketball players during competition. *Journal of Sports Sciences, 13*(5), 387–397.

McCormick, B. T. (2014). The reliability and validity of various lateral side-step tests. *International Journal of Applied Sports Sciences, 26*(2), 67-75.

Montgomery, P., Pyne, D., & Minahan, C. (2010). The physical and physiological demands of basketball training and competition. *International Journal of Sports Physiology and Performance, 5*, 75–86.

Morrison, M., Martin, D.T., Talpey, S., Scanlan, A.T., Delaney, J., Halson, S., & Weakley, J. (2022). A Systematic Review on Fitness Testing in Adult Male Basketball Players: Tests Adopted, Characteristics Reported and Recommendations for Practice. *Sports Medicine*, Online first: https://doi.org/10.1007/s40279-021-01626-3

Narazaki, K., Berg, K., Stergiou, N., & Chen, B. (2009). Physiological demands of competitive basketball. *Scandinavian Journal of Medicine Science and Sports, 19*, 425–432.

Nimphius, S., Callaghan, S. J., Bezodis, N. E., & Lockie, R. G. (2018). Change of direction and agility tests: challenging our current measures of performance. *Strength and Conditioning Journal, 40*(1), 26–38.

Oliver, J., & Meyers, R. (2009). Reliability and generality of measures of acceleration, planned agility, and reactive agility. *International Journal of Sports Physiology and Performance. 4*, 345-354.

Paul, D. J., Gabbett, T. J., & Nassis, G. P. (2016). Agility in team sports: Testing, training and factors affecting performance. *Sports Medicine, 46*(3), 421-442.

Rodriguez-Alonso, M., Fernandez-Garcia, B., Perez-Landaluce, J., & Terrados, N. (2003). Blood lactate and heart rate during national and international women's basketball. *Journal of Sports Medicine and Physical Fitness 43*, 432–436.

Roozen, M. (2005). Developing hip joint adduction and abduction strength. *NSCA Perform Train J* 4: 18–19.

Sattler, T., Sekulic, D., Spasic, M., Osmankac, N., Vicente, J. P., Dervisevic, E., & Hadzic, V. (2016). Isokinetic knee strength qualities as predictors of jumping performance in high-level volleyball athletes: multiple regression approach. *The Journal of Sports Medicine and Physical Fitness, 56*(1-2), 60-69.

Scanlan, A., Dascombe, B., & Reaburn, P. (2011). A comparison between the activity demands of elite and sub-elite Australian man's basketball competition. *Journal of Sports Sciences*, 29:11, 1153-1160.

Scanlan, A., Dascombe, B., Reaburn, P., & Dalbo, V. (2012). The physiological and activity demands experienced by Australian female basketball players during competition. *Journal of Science and Medicine in Sport 15*, 341–347.

Sekulic, D., Krolo, A., Spasic, M., Uljevic, O., & Peric M. (2014). The development of a new stop'n'go reactive agility test. *Journal of Strength and Conditioning Research, 28*(11), 3306-3312.

Sekulic, D., Pehar, M., Krolo, A., Spasic, M., Uljevic, O., Calleja-González, J., & Sattler, T. (2017). Evaluation of Basketball-Specific agility: applicability of preplanned and nonplanned agility performances for differentiating playing positions and playing levels. *Journal of strength and Conditioning Research, 31*(8), 2278–2288.

Serpell, B.G., Young, W.B. & Ford, M. (2011). Are Perceptual and Decision-Making Components of Agility Trainable? A Preliminary Investigation, *Journal of Strength and Conditioning Research, 25*, 1240- 1248

Shimokochi, Y., Ide, D., Kokubu, M., & Nakaoji, T. (2013). Relationships Among Performance of Lateral Cutting Maneuver From Lateral Sliding and Hip Extension and Abduction Motions, Ground Reaction Force, and Body Center of Mass Height. *Journal of Strength and Conditioning Research, 27*(7), 1851–1860.

Spasic, M., Krolo, A., Zenic, N., Delextrat, A., & Sekulic, D. (2015). Reactive agility performance in handball: Development and evaluation of a sport-specific measurement protocol. *Journal of Sports Science & Medicine, 14*, 501–506.

Spiteri, T., Cochrane, J. L., & Nimphius, S. (2013). The Evaluation of a New Lower-Body Reaction Time Test. *Journal of Strength and Conditioning Research, 27(1),* 174–180.

Sporiš, G., Šango, J., Vučetić, V., & Mašina, T. (2006). The latent structure of standard game efficiency indicators in basketball. *International Journal of Performance Analysis in Sport, 6*(1), 120-129.

Uchida, Y., Demura, S., Nagayama, R., & Kitabayashi, T. (2013). Stimulus Tempos and the Reliability of the Successive Choice Reaction Test. *Journal of Strength and Conditioning Research, 27(3),* 848-853.

Veale, J., Pearce, A., & Carlson, J. (2010). Reliability and validity of a reactive agility test for Australian football. *International journal of sports physiology and performance*, *5*(2), 239-248.

Zouhal, H., Abderrahman, A. B., Dupont, G., Truptin, P., Le Bris, R., Le Postec, E., Coppalle, S., Ravé, G., Brughell, M., & Bideau, B. (2018). Laterality influences agility performance in elite soccer players. *Frontiers in Physiology*, 9, 807.

VALIDNOST I POUZDANOST TESTA ZA PROCENU VREMENA REAKCIJE I BRZINE KRETANJA U ODBRAMBENOM KOŠARKAŠKOM STAVU

Cilj aktuelnog istraživanja bio je da se ispita validnost i pouzdanost novoosmišljenog testa za procenu vremena reakcije i brzine kretanja u odbrambenom košarkaškom stavu (RTADST). Trideset šest košarkašica iz tri kluba profesionalne nacionalne lige Bosne i Hercegovine (godine: 18.81 ± 2.58) realizovalo je šest odvojenih izvođenja testa RTDST, gde se svako izvođenje sastojalo od brzih bočnih kretnji ulevo i udesno. Sportistkinje su izvele tri pokušaja u jednom danu, a ponovljeno testiranje je izvedeno sledećeg dana za vreme večernjeg košarkaškog treninga. Relativna pouzdanost RTADST testa je evaluirana putem koeficijenta Cronbach alpha i ICC. Cronbach alpha koeficijent je iznosio 0.81 što se smatra dobrom pouzdanosti. Uzimajući u obzir preporuke Bucheit i saradnika (2011), vrednost ICC <0.69 se smatra slabijom pouzdanosti. Apsolutna pouzdanost RTADST je procenjena putem CV, čija vrednost je iznosila 5.3%, odnosno nešto iznad 5%, što predstavlja granicu prihvatljive pouzdanosti. Međutim, pokazatelji relativne i apsolutne pouzdanosti nakon izostavljanja prvog pokušaja (familijarizacija sa motoričkim zadatkom), bili su prihvatljiviji. Koeficijent Cronbach alpha je iznosio 0.90, a ICC = 0.82 u poređenju sa pokazateljima koji su uključivali sva tri pokušaja. Imajući u vidu apsolutnu pouzdanost, može se zaključiti da je test pouzdan jer vrednosti CV su ispod 5% (3.9%). Pouzdanost između dva dana procenjena je putem ICC, čija vrednost je bila 0.74, što potvrđuje dobru pouzdanost. Na kraju, test RTADST se može smatrati validnim testom koji diskriminiše vanjske i unutrašnje košarkašice u vremenu reakcije i brzine kretanja u odbrambenom košarkaškom stavu. Kondicioni programi za razvoj ovih sposobnosti treba da budu sprovedeni uz primenu RTADST kao alata za inicijalnu i finalnu evaluaciju tih sposobnosti.

Ključne reči: *Procena agilnosti, neplanirana agilnost, košarkašice.*

FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 20, No 1, 2022, pp. 73 - 87
https://doi.org/10.22190/FUPES220225007T

Research article

CAN A PHYSICAL ACTIVITY PROGRAMME IMPROVE THE QUALITY OF LIFE IN YOUTH WHO LIVE IN AN ORPHANAGE? A MIXED METHODS STUDY

UDC 796.012.1:725.578-053.6
796:613.955

Konstantina Trampa, Fotini Venetsanou

School of Physical Education and Sport Science,
National and Kapodistrian University of Athens, Athens, Greece

Abstract. *Physical activity (PA) is thought to positively contribute to the improvement of the (poor) Quality of Life (QoL) of youth living in institutions. However, youth's participation in PA can be affected by the "significant others" in their life. The aim of this study was to (a) investigate the impact of a PA programme on the QoL of youth hosted in an orphanage and (b) understand the role of the relationships formed in this institution in the outcome of the programme objectives. For that purpose, a mixed methods approach was adopted. The study was conducted in an orphanage in Attica, Greece. Twelve of the 13 male orphans (Mage= 13.08 ± 2.43 years) participated in a 10-week PA programme implemented in the institution. The KINDL® questionnaire was completed by the orphans and one caregiver before and after the PA intervention. The qualitative data were collected through observation and semi-structured interviews with 12 orphans and 6 members of the orphanage staff. The results showed that orphans' QoL levels were poor; whereas a statistically significant decline in their total KINDL® scores (p= .033) and the Emotional Well-Being subscale (p= .013) was identified. Quality data revealed that orphans' participation in the PA programme was inconsistent, although they estimated that it was valuable. Intra- and inter-personal factors emerged as barriers for PA participation. It seems that living in an institution results in deep deteriorations in youth's QoL that cannot be surmounted by their participation in a PA programme.*

Key words: *sports, orphans, well-being, health*

Received February 25, 2022 / Accepted April 11, 2022
Corresponding author: Fotini Venetsanou
School of Physical Education and Sport Science, National and Kapodistrian University of Athens, Athens, Greece
E-mail: fvenetsanou@phed.uoa.gr

INTRODUCTION

Quality of Life (QoL) is defined as an "individuals´perception of their position in life in the context of the culture and value systems in which they live … [that is] affected in a complex way by the person's physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to salient features of their environment" (WHO, 1995). QoL is very important to human life, as it determines the prosperity and well-being of people, having a direct impact on individual- and public health (WHO, 2015).

One of the most disadvantaged groups in terms of QoL is youth, who live in child protection settings (Purohit, Pradhan, & Nagendra, 2016a; Quarmby, 2014). There are several reasons for their poor QoL, including the fact that they are deprived of a parent figure and a specific reference person (Konijn et al., 2019), they do not receive personalized care (Sebsibe, Fekadu, & Molalign, 2014) and they have often been exposed to traumatic events (D'Andrea, Bergholz, Fortunato, & Spinazzola, 2013). Many times, all the above result in deviant or even delinquent behaviors (Leslie et al., 2010; Tarullo, Bruce, & Gunnar, 2007), as well as physical and mental health problems (Heinrich & Gullone, 2006; Kearns, Whitley, Tannahill, & Ellaway, 2015; Kolayiş, Sarı, Soyer, & Gürhan, 2011; Tarullo et al., 2007).

Physical Activity (PA), either free (Hyndman, Benson, Lester & Telford, 2017) or organized (Farmer et al., 2020; Georgiev & Gontarev, 2019), is thought to positively affect youth's QoL, offering a holistic framework for social-psychological-physical development (Hyndman et al., 2017; Moati, 2014). That is also the case for youth living in institutions. Indeed, several studies (Akhmetshin et al., 2019; Çelebi, Alkurt, Mirzeoğlu, & Şemşek, 2005; Culver, Whetten, Boyd, & O'Donnell, 2015; D'Andrea et al., 2013; Hanrahan, 2005; Kolayiş et al., 2011; Moati, 2014; Purohit & Pradhan, 2017; Purohit et al., 2016a, b; Ramadan, 2014) have demonstrated that PA can positively contribute to the improvement of various aspects of QoL in youth who live in institutions.

Nevertheless, it is well known that the participation of youth in PA can be affected by the environment in which they are growing up (Macdonald et al., 2004). The relationships of children and adolescents with "significant others" in their life, such as parents (Dagkas & Stathi, 2007), and/or friends (Smith, 2003) can either support or impede their engagement with PA. Based on the above, it seems that if PA is to be used as an effective means for the enhancement of the (poor) QoL of youth living in institutions both in the short and in the long term, light should be shed into the relationships that are formed in the institution, in which the PA program is applied. However, until now, all the published studies focusing on PA in youth living in institutions are quantitative in nature; to our knowledge, there is no published study providing such qualitative evidence so far. Thus, the aim of this study was to investigate the impact of a PA program on the QoL of youth hosted in an orphanage, as well as to understand the role of the relationships formed in this institution in the outcome of the program objectives.

METHOD

Design

A mixed methods approach was utilized as it strengthens research evidence (Creswell & Creswell, 2019) and provides insight into the topic to be explored that may be missed

when only a single method (quantitative or qualitative) is used (Johnson & Onwuegbuzie, 2004). Both types of data (i.e. qualitative and quantitative) were collected during the same phase of the research and merged during analysis and interpretation (Creswell & Creswell, 2019).

Setting/participants

The study was conducted in an orphanage in Attica, Greece, between December, 2020 and February, 2021. The orphanage provides free accommodation, food, clothing, footwear, education, sports participation fees, and medical care to orphan and needy males aged 7-16 years. During this study, the orphanage hosted in total 13 males, aged 9-17 years (13.08 ± 2.43 years). Among them, one adolescent refused to participate and was excluded from the study.

The institution staff consisted of the director, a social worker, a psychologist, an accountant, seven caregivers (4 women, 3 men), kitchen staff, and cleaning staff. Caregivers were responsible for the everyday care (school homework, behavior, hygiene, etc.) of the orphans. Most of them have a university degree in Humanities and had been working in child protection centers for more than 10 years.

Quantitative data collection

The KINDL® questionnaire (Ravens-Sieberer & Bullinger, 2000), adapted for the Greek population (Vidali, Vidalis, Ravens-Sieberer, & Bullinger, 2001), was used to assess the orphans' QoL. Specifically, the KINDL® versions for ages 8-12 years (Kid-KINDL®) and 13-17 years (Kiddo-KINDL®) were administered. Moreover, the parent version of the KINDL® for children aged 8-16 was completed by a female caregiver, who had been working at the orphanage for 14 years.

All the KINDL® versions include 24 items that are classified into six subscales/QoL dimensions: Physical well-being; Emotional well-being; Self-esteem; Family; Friends (social contacts); Everyday Functioning (school). Children and adolescents are asked to check the answer that they consider closest to their personal experience; whereas the caregivers are asked to assess their QoL. Each question is answered in a five-point Likert scale (never = 1, rarely = 2, sometimes = 3, often = 4, constantly = 5); whereas some of them have a reverse score. As far as the psychometrics of the KINDL® are concerned, both its reliability and validity are sufficiently supported (Ravens-Sieberer & Bullinger, 2000). Also in this study, the internal consistency was supported (Cronbach's alpha values ranged from .64 to .86).

The KINDL® was completed by the orphans and the caregiver before and after the implementation of the PA intervention program.

Qualitative data collection

Qualitative data were gathered through observations and individual interviews conducted by the first author. Observations took place during the period of PA programme implementation (both during PA sessions and before/after them) and aimed at observing orphans' and orphanage staff's behaviours and their interaction. For that purpose, an observational protocol was designed, in which descriptive and reflective notes about the PA programme along with notes regarding interactions and events were included. In order to obtain a rich narrative description of the context, notes were written as soon as possible after the observation (Creswell & Creswell, 2019).

Individual semi-structured interviews with 12 orphans and six members of the orphanage staff [director; psychologist; social worker; three caregivers (two females; one male)] were conducted by the first author at the end of the intervention in order to obtain a deeper understanding of their perceptions regarding the programme, as well as the barriers that may have shaped its delivery and acceptance. For that purpose, two flexible interview guides (one for the orphans and one for the staff), consisting of five questions each (Creswell & Creswell, 2019) were consistently applied in all the interviews. The interview questions for the youth asked of them to evaluate the programme and provide their response to the programme. The interview questions for the staff asked of them to evaluate the programme and the youth's response to it, as well as to identify reasons for the youth's inconsistent participation, and to make suggestions for the programme's improvement.

All interviews were conducted in the Greek language (all the participants were native speakers of Greek), in a quiet room, were digitally recorded, and lasted approximately 25 minutes. Written and verbal informed consent was obtained by the adults and youth participants, respectively, before all the interviews.

Procedure

The research was approved by the administrative council of the institution in November 2020 as well as by the University Ethics committee. Then, an informative meeting was held in the orphanage, in which the staff and the orphans were informed about the purpose and the procedures of the study and were assured that their participation would be anonymous and voluntary. All the participants (orphans and staff) provided their informed consent verbally. PA intervention was intended for all the orphans (they were not divided into an experimental and a control group), as it was considered important to give everyone the opportunity to benefit from the PA.

Physical activity programme

The PA programme was informed by the pedagogical principles of Physical Education and was based on the specific needs of youth that are hosted in child protection institutes (Heinrich & Gullone, 2006; Kearns et al., 2015). It was designed through the cooperation of the authors with the psychologist and the social worker of the institution; whereas, orphans' opinions about the activities included were taken into account and a variety of student-centered games and activities (Akhmetshin et al., 2019) took place, so as to encourage them to be physically active with autonomy, after the end of the program intervention (Çalik et al., 2018).

The programme was implemented by the first author, who has a physical education bachelor degree, and lasted 10 weeks (7/12/2020 - 27/2/2021) during the period of the second quarantine in Greece. In the first three weeks, it included team games, as well as basketball and soccer technical exercises and took place in the institution. After the Christmas holidays, activities outside the institution (hiking, football in the fields and on the beach, etc.) were added. The last three weeks, it consisted mainly of walks and activities in the natural environment, due to the preference of the participants for outdoor activities compared to those at the institution. The participants were divided into two groups (group a: n= 6 orphans, aged 9-12 years; group b: n= 6 orphans, aged 13-17 years). In total, 20 30-60 minutes PA sessions took place for each group.

Analyses

For quantitative data, the average scores regarding the orphans' QoL reported by the participants and the caregiver were first calculated, and intraclass correlation coefficients (ICCs), type 2.1, were computed to examine the agreement between their scores. Then, paired t-tests were implemented on orphans' scores to detect potential differences between the pre-and post- intervention regarding their total and KINDL® subscales scores. All statistical analyses were computed with the SPSS v25.0 software (IBM SPSS, Inc., Chicago, IL, USA), and the level of significance was set at 0.05.

For qualitative data, thematic analysis was conducted using all available data (i.e., interview transcriptions, field notes from observations) in order to identify, analyze, and report patterns. Common answers and observations were firstly coded and then organized into themes. Moreover, significant quotations reflecting the core of the themes were extracted and translated from Greek to English.

RESULTS

Quantitative data

Descriptive statistics regarding the orphans' QoL as it was assessed by them and the caregiver before and after the PA intervention implementation are presented in Table 1.

Table 1 Descriptive statistics (M, SD) of the inmates' QoL assessed by themselves and the caregiver at the pre- and post-test

	Pre-test		Post-test	
KINDL® Sub - Scale	Inmates	Caregiver	Inmates	Caregiver
Physical Well - Being	76.87 ± 19.78	58.17 ± 16.41	73.13 ± 12.52	64.42 ± 16.41
Emotional Well - Being	46.87 ± 14.80	47.59 ± 13.87	32.5 ± 17.38*	56.25 ± 14.43
Self – Esteem	54.37 ± 20.84	37.5 ± 14.88	50 ± 18.63	47.6 ± 8.28
Family	33.33 ± 20.8	36.1 ± 10.87	35.41 ± 20.25	39.2 ± 11.21
Friends	60.62 ± 21.26	61.54 ± 17.28	63.13 ± 12.31	67.71 ± 7.92
School	51.88 ± 14.45	34.61 ± 17.42	48.13 ± 17.93	36.46 ± 14.56
Total KINDL® score	57.18 ± 7.79	45.91 ± 10.10	49.30 ± 7.51*	50.76 ± 8.09

*Statistically significant differences between pre- and post-test were detected.

As it was revealed by the ICCs that were computed, the agreement between the youth's assessment of their QoL and its assessment by the caregiver was poor. Specifically, at the pre-test the ICC ranged from .07 (School) to .59 (Emotional Well - Being); whereas, at the post-test it ranged between .01 (Friends) and .74 (Physical Well - Being) at the post-test. Due to this discrepancy, only the orphans' scores were used for the analyses regarding the impact of PA program on the orphans' QoL.

According to the paired t-tests, a statistically significant decline was revealed at the post-test in the orphans' total KINDL® scores [$t(12)=2.5$, $p= .033$] and in the Emotional Well - Being subscale [$t(12)= 3.08$, $p= .013$]. No other significant differences were detected.

Qualitative data

As far as the qualitative data are concerned, the codes were sorted into three main categories of themes, including the PA programme evaluation; the orphans' response to the programme; and barriers for the orphans' participation.

PA programme evaluation

Most of the orphans (n=10) stated the PA programme was valuable and they would like to have it on a regular basis; whereas, seven said that it improved their QoL because it offered them opportunities for physical exercise. The staff agreed that the PA programme was very helpful, especially at that specific period, when – due to the country lockdown – the orphans did not have any other activities outside the institution, and positively contributed to the orphans' QoL.

"…the programme helped also the relations among the orphans, through its team activities. For some of them that impact was not obvious; they had never played together. You offered us the prospect to move ahead". (Psychologist)

Orphans' response to the programme

Field notes revealed that orphans' participation was not consistent. In each session, on average two boys per group (not always the same ones) did not participate. However, nine of them estimated that their participation was sufficient; three admitted that they did not consistently participate due to different reasons, each ["T" (14 years old) said he could not regularly participate due to allergies; "W" (15-year-old) due to shortage of time; "A" (15- year-old) said "*I was bored. I would have participated more if everybody had taken part*"].

Indeed, adolescents' participation heavily depended on whether their peers took part or not. Moreover, it was observed that during the first sessions the orphans found it difficult to cooperate; however, after some weeks they shared their ideas for team games.

Barriers for orphans' participation

Regarding the barriers for the orphans' participation in the programme, both intra- and inter-personal factors emerged.

- Intra-personal factors:

The staff recognized that one of the barriers to the orphans' participation in the programme was their (bad) psychological status.

"There are several reasons for an orphan's non-participation that are relative to their psychological status. Some of them are in a constant bad mood and that has nothing to do with the instructor or the content of the programme." (Caregiver, male).

"These children are hurt and they offer what they can afford to […]. They do not have anything stable in their life and that is reflected in their every step. The worst home is better than the best institution. We are an institution, institution, institution; the worst that could have happened to them! The child must be very well organized within themselves, to show stability in sports, at school, in everything. […] This starts from within them. They have difficulties following a program. Children in institutions are a special category and when I say "special" I mean that they have different needs than

children living in their own homes. Their psychological strength is limited. If only someone could consider how many reference persons a child living in an institution encounters in twenty-four hours…" (Caregiver, female).
"These children are psychologically traumatized. They are not emotionally strong. […]" (Caregiver, female).

Strongly attached to the orphans' psychological status was their engagement with computers. Some boys very often, if they had access to computers, chose not to participate in the PA program so as not lose time from the online computer game they played. Furthermore, the staff emphasized that the boys spent many hours in front of computers, which they believed stems from past traumas and bad experiences at the institution.
"The only thing that concerns P is the internet and the Fortnite game. He does not even attend his classes, while the same time – of course – he is not interested in sports. He is another child in chaos…He does not know what will happen in the future… The internet is a way to forget. He is very sensitive and he knows very well how to hide; he has a lot of pain inside him." (Caregiver, female)
"T told me once: "I do not want to study; I do not want to do anything". It is exactly what happens with many of the orphans… he has no courage for anything; he gets lost in a computer and he has many reasons for doing so…and he is right! He does not have anyone waiting for him. […] Since his mom and dad have not been able to stand in front of him to tell him "We love you. You are precious to us", the child is trying to find the meaning of his life and it will take him many years to find it." (Caregiver, female)

Finally, feeling embarrassed was identified as a barrier for the orphans' participation in PA. Younger orphans were keen on walks outside the orphanage. However, four of the adolescents hesitated to take part, so as not to be recognized as "the children of the institution". Furthermore, when they participated they seemed anxious not to meet a classmate and walked in distance from each other. Many times they preferred to take a different route and pretended not to know each other.
"Will we all go out as a group? It will seem that we are from the institution…" ("P", 14-year-old).

However, it should be noticed that on the way back to the institution, they did not seem to care about this issue and followed the group in a great mood for conversation.

The biggest concern for one of the adolescent orphans was that he felt embarrassed because his clothes were not the right fit anymore. Nevertheless, when the first author offered him her jacket, he was very happy and participated in the walk.

- Inter-personal factors:

The way the institution operated was an obstacle for PA programme implementation. To begin with, the inability of the staff to implement the rules was revealed. For example, the director, the psychologist and the social worker co-decided that while the programme was taking place, the orphans would not have access to the computer room. This rule was not followed by all the caregivers.
"…We did not have a common attitude towards the programme. Some of the caregivers followed what we had agreed; whereas some others did not. That inconvenienced us…" (Social worker)

"The success of a programme requires preparation and good coordination on our part first. […] That does not happen… it never happens. That's why there was a problem with the orphans' response to the PA programme. […]" (Caregiver, female)

A lack of common practices and rules was noticed across all the aspects of the daily life in the orphanage. For example, several times, when the orphans should be doing their schoolwork, they were allowed to play electronic games, resulting in them not finishing their studies. Inconsistency was also observed at meal times, as, for several days, there were children who missed one of the meals (e.g., breakfast), because they may not have been woken up or were busy, mainly at the computers.

"The attitudes of the caregivers are very important. The child often does not understand what is good for them; we have to teach them. Unfortunately, this is not the case here. Caregivers do not have a common attitude towards orphans. These deficits are obvious in their studying, meals, sleep. Some caregivers do not care or cannot bear to set limits; however, when we do not obey the rules how could we teach them to children? […]" (Caregiver, female)

"Two and a half years now, we have not managed to eat all together even once." (Director)

It was obvious that the daily routines at the orphanage were not in line with a programme.

"… The problem is that we do not have a program implementation culture […]. When I came here, I did not find any sort of program. I designed one; however, the orphans have found it very difficult to follow it… One of them told me "before you arrived, I went to school whenever I wanted" [...]. That boy threatened to stab me […]." (Director)

"Before this director, the situation here was somewhat out of control. The orphans did whatever they wanted. You cannot imagine what happened here. I even found the bolts of my car unscrewed." (Caregiver, female)

Furthermore, several members of the staff emphasized the bad relationships of the orphans with the Director.

"Their inaction is due to opposition" (Social worker)

Some boys expressed their disagreement with the Director's decision to lock the computer room at the hours of PA programme implementation; whereas, some others attributed those behaviours to the bad relationships of the youth with the Director.

"Since the PA programme was presented by the Director some of the orphans did not want to participate due to their bad relationship with him" (Psychologist)

"The changes I brought were not easy for them. They are not used to these changes and they cannot accept them. […]" (Director)

Finally, the relationships among the orphans were bad too. It seemed that the orphans had not developed a sense of being a team. Although they went to the same school, they often reported that during school hours, they did not talk to each other and preferred not to hang out. Moreover, as it was earlier reported, they faced difficulties in participating in group PA. The observation of their free play revealed that it included notable violence (hitting each other; use of abusive words). Sometimes their play took the form of a fight, with the older boys ordering the younger ones to simultaneously hit a slightly older child all over his body. This "game" ended, when the orphan, who "ordered" the fight decided so, or when one of the "fighters" was seriously hurt, or when a staff member noticed what happened. Furthermore, several boys mistreated the animals of the institution (e.g., they stuck chewing gum on and threw things at the dog).

Violent behaviours were the main way the boys expressed themselves, especially when they felt that they could not handle a situation. One day, when the young children

were finishing their school work, just before a PA session, "K" (9-year-old), obviously annoyed by a disagreement with the caregiver about his exercises and a comment by "G" (11-year-old), started shouting. The caregiver left the study room to let him calm down, and "K" took a chair and threw it towards "G".

"In previous years the older boys were in control. Hierarchical relationships, fear, and obedience prevailed among the orphans; a situation usually found in reformatories."[…] (Director)

DISCUSSION

Research evidence reveals that PA can positively contribute to the improvement of the (poor) QoL of youth living in institutions (Akhmetshin et al., 2019). However, as youth's participation in PA can be affected by the "significant others" in their life (Dagkas & Stathi, 2007; Smith, 2003), the relationships that are formed in an institution should be investigated if effective PA interventions aiming at the improvement of the QoL of young orphans are to be implemented. To our knowledge, this was the first study attempting to both examine the impact of a PA program on the QoL of youth hosted in an orphanage and understand the role of the relationships formed in this institution in the outcome of the program objectives, using a mixed methods approach.

Our key findings were that the PA programme that was implemented for 10 weeks did not significantly improve the orphans' QoL, as youth did not consistently take part, despite the fact that they estimated the programme as valuable. Both intra- and inter-personal factors acted as barriers for the youth's participation in the programme and negatively affected their QoL.

Starting with the quantitative data, the initial levels of the orphans' QoL expressed by the total KINDL® scores, though slightly higher than those of Turkish adolescents living in orphanages (46.47 ± 15.60) (Çaman & Özcebe, 2011), were low. However, the scores of our participants were much poorer than those of typical Greek youth living in families (Ginieri - Coccossis et al., 2013; Rotsika et al., 2016; Rotsika et al., 2011). For example, the scores of the orphans on the Emotional Health and the Family subscales were 46.87±14.80 and 33.33±20.8, respectively; whereas, the scores of their peers living in families on those subscales exceeded 76 points (Ginieri-Coccossis et al., 2013; Rotsika et al., 2016, 2011). Moreover, higher scores on the KINDL® subscales than those presented in this study have been found in youth with learning disabilities (Ginieri - Coccossis et al., 2013; Rotsika et al., 2011) and migrants (Rotsika et al., 2016), with the exception of the Self-Esteem subscale, where KINDL® scores were similar to the present ones.

An explanation for the above finding can be the fact that the general psychological and physical development of youth growing up in families (Bettmann, Mortensen, & Akuoko, 2015) differs from the development of their peers left without parental care, who lack personalized care (Sebsibe et al., 2014), a stable living environment, and specific reference persons (Konijn et al., 2019). Several researchers argue that the conditions these youth encounter result in feelings of loneliness (Moati, 2014), anxiety (Heinrich & Gullone, 2006; Kearns et al., 2015), depression (Heinrich & Gullone, 2006), and aggressive behaviours (Leslie et al., 2010). The aforementioned are negatively associated with QoL (Çaman & Özcebe, 2011; Kolayiş et al., 2011). According to Tümkaya (2005), the main reason why orphans face difficulties in their lives is that they

lack the emotional satisfaction they could have from their family and relatives. During the interviews, the caregivers said that these youth were hurt, with nothing stable in their lives, and attributed the heavy engagement of orphans with computers to their lack of emotional satisfaction and their effort to "forget their problems".

Youth living in childcare settings present low scores on the School and Friends KINDL® subscales, as they often have severe learning disabilities and inability to meet their academic obligations (Quarmby, 2014); thus, they tend to drop out of school (Smyke et al., 2002). This was also demonstrated in the present study, with the Director pointing out the great difficulty the orphans faced in school, with numerous school absences and very poor grades. Several researchers suggest that orphans' poor academic achievement leads to low levels of self-esteem, as they are possessed by a sense of inferiority compared to their peers, resulting in their inability to create interpersonal relationships (Kalyva, 2016; Kiambi & Mugambi, 2017). Frequent failures to be integrated into a peer group and engage in group activities appears to be a combination of emotional, interpersonal, and behavioural weaknesses (Lyons, Uziel-Miller, Reyes, & Sokol, 2000) that cause difficulties in social interaction and relationships with peers (Tarullo et al., 2007). In the present study, it was revealed that the orphans had not managed to develop healthy relationships, mistreating the younger children and the pets of the institution; whereas, violence (vocal and physical) prevailed in their interaction. Institutionalization is thought to promote social stigma (Link & Phelan, 2001). In the present study four out of twelve participants, feeling the stigma of "institution child", were quite anxious not to meet a friend or schoolmate, whenever the PA program included a walk outside the institution.

A finding worth discussion is the low orphan-caregiver concordance about the QoL of the orphans. This could be attributed to the fact that, in contrast to youth growing up with their parents (Ginieri - Coccossis et al., 2013; Kiss et al., 2009; Rotsika et al., 2011), those living in institutions do not have a specific reference person corresponding to a parent figure, who has substantial knowledge of their daily needs (Konijn et al., 2019). Nevertheless, low agreement on the evaluation of QoL between the scores of children and their parents is often reported (Ginieri - Coccossis et al., 2013; Rotsika et al., 2011). It should be noted that divergences of parent-child perceptions are found mainly in the areas of QoL, where the child seems to be experiencing difficulties, since children underestimate the problem they are experiencing, rating themselves higher than their real status (Kiss et al., 2009). In the same way, parents of children with learning disabilities seem to overestimate some areas of their offspring's QoL in order to balance the deficit the child may face (Ginieri - Coccossis et al., 2013; Rotsika et al., 2011). It seems that in the present study, the Caregiver, being aware of the low levels of QoL of orphans in some areas (e.g. Family, School), presented higher scores in some other categories (e.g. Emotional health, Friends).

As far as the impact of the PA programme on orphans QoL is concerned, according to the KIND® scores, statistically significant decreases in the total KINDL® scores and the Emotional Well-Being subscale scores were revealed; whereas, slight improvements, though of not statistical significance, were noticed for the Physical Well-Being and Friends subscales. This lack of QoL improvements is in disagreement with previous experimental studies examining the effects of PA programmes on youth living in institutions (Akhmetshin et al., 2019; Çelebi et al., 2005; Culver et al., 2015; D'Andrea et al., 2013; Kolayiş et al., 2011; Moati, 2014; Purohit & Pradhan, 2017; Purohit et al., 2016a, b; Ramadan, 2014). A potential factor that may have negatively affected the results of the present PA programme was the small number (n=12) and the wide age range (9 -17 years)

of the participants that did not allow for real team games. In the above studies that report positive outcomes of the PA, the participants were of approximately the same age, forming more homogenous groups.

Nevertheless, it should be noted that those studies focused on specific QoL variables, such as physical fitness (Purohit et al., 2016; Ramadan, 2014), attitudes towards regular participation in sports (Çelebi et al., 2005), cognitive abilities (Purohit & Pradhan, 2017; Ramadan, 2014), self-esteem and anxiety (Kolayiş et al., 2011), loneliness (Moati, 2014; Purohit et al., 2016b), mental health and behaviour (Akhmetshin et al., 2019; Culver et al., 2015; D'Andrea et al., 2013; Ramadan, 2014); thus, they do not provide a comprehensive picture of the QoL. Furthermore, the distinct differences among the programmes implemented in those studies should be emphasized, as they impede the comparison of their results and conclusions being drawn about which programme can be effective. For example, the shortest intervention lasted one month (Ramadan, 2014) and the longest seven months (Akhmetshin et al., 2019)]; whereas, the PA content included yoga sessions (Culver et al., 2015; Purohit & Pradhan, 2017; Purohit et al., 2016a,b), football (Akhmetshin et al., 2019), basketball (D'Andrea et al., 2013) or various sport activities (Çelebi et al., 2005).

Moreover, the period during which the PA programme in this study was implemented (i.e. during a country lock-down due to the second wave of the COVID-19 pandemic) may have played a vital role, since the orphans were confined exclusively to the orphanage. According to the literature, the changes in the youth's daily life caused by the pandemic are associated with large effects on their QoL; especially in their physical and mental health (Fore, 2020; Orben, Tomova, & Blakemore, 2020). It seems that the PA programme, although leading to improvements on some KINDL® subscales (Physical Well-Being; Friends), could not overcome the deterioration of the QoL caused by the quarantine.

In contrast to the statistical results, the majority of orphans reported that the PA programme was beneficial for their QoL and that they would like to receive it regularly. The staff of the orphanage were on the same page. Nevertheless, the field notes revealed that the orphans' participation was not consistent, even though they thought so. They may have not been able to accurately assess their participation or they were not aware of what consistent participation means. Qualitative data offered valuable information about the barriers for the orphans' participation and revealed deeper problems in the relationships within the institution. As mentioned earlier, intra-personal factors were reported and observed. As it was earlier discussed, the orphans' poor psychological status was pointed out by the staff. Moreover, the orphans spent a lot of time in front of computers. However, it is known that excessive screen time is associated with the multiple negative effects on youth's physical, mental, and social development (Gentile & Anderson, 2006). This is a global phenomenon with youth presenting screen time of approximately eight hours per day (Reid, Radesky, Christakis, Moreno, & Cross, 2016; Rideout, Foehr, & Roberts, 2010).

Furthermore, the relationships developed within the institution were problematic. Orphans had not developed the sense of being a team; as the psychologist noted, they had never played together; that is why they faced difficulties in group PA activities. Nevertheless, they showed slight improvements in the Friends KINDL® subscale. It seems that the impact of the PA programme was not strong enough to overcome the hierarchical relationships that were both observed and reported or the extreme behaviors and violence of all kinds that were particularly prevalent. These findings are not rare in youth living in institutions (Leslie et al., 2010; Tarullo et al., 2007) and should be taken into account when a PA intervention for this population is designed.

However, one of the most important barriers seemed to be the way the institution operated. Menzies-Lyth (1985) argues that the key-factors for the operation of an institution are its administration and its members' communication/cooperation. In this study, a lack of cooperation within the staff was revealed, resulting in their inability to maintain common caregiving practices, which had negative consequences not only for the PA programme implementation but also for the orphans' daily life. The director's confession that they had not managed to eat all together even once in two and a half years shows that these youth are growing up in the absence of a warm and concrete context. Also, Kalyva (2016) states that the conditions in institutions are negative not only for the orphans, but also for the staff, who feel that they do not have enough training, support, and supervision in order to be effective. She also argues that the time children spend in institutions is an aggravating factor for their lives and that children of foster families, having spent less time in child care facilities, have been found to be less burdened by the symptoms of institutionalization (Kalyva, 2016).

This study has some limitations that should be taken into account when interpreting its results. To begin with, the intervention took place during the quarantine due to the COVID-19 pandemic and not in a "normal" period. This (negatively) affected the results of the PA programme; however, it is unknown to what degree. Moreover, the group of orphans was quite small, resulting in the absence of a control group; thus, our sample consisted only of males of a wide age range; this restricted their interaction within the programme; furthermore, our findings cannot be generalized to female orphans. Nevertheless, this is the first study to investigate the impact of a PA intervention on youth living in an orphanage, using a mixed methods approach. This is the strength of the study, since this approach enhances research evidence (Creswell & Creswell, 2019) and offers a unique insight into the topic that may have been missed in studies using only a single method (Johnson & Onwuegbuzie, 2004).

CONCLUSIONS

The QoL of youth living in an orphanage is poor and their participation in a 10-week PA programme implemented at the institution cannot significantly improve their QoL. Both intra- and inter-personal factors associated with their living at the orphanage act as barriers for youth's participation in the programme and negatively affect their QoL. In this specific orphanage, the way it operated caused further problems for the orphans' lives. It seems that living in an institution results in deep deteriorations in youth's QoL that cannot be surmounted by their participation in a PA programme.

REFERENCES

Akhmetshin, E. M., Miftakhov, A. F., Murtazina, D. A., Sofronov, R. P., Solovieva, N. M., & Blinov, V. A. (2019). Effectiveness of using football basics in physical education and organizing arts and cultural events for promoting harmonious development of orphan children. *International Journal of Instruction*, *12*(1), 539-554.

Bettmann, J. E., Mortensen, J. M., & Akuoko, K. O. (2015). Orphanage caregivers' perceptions of children's emotional needs. *Children and Youth Services Review*, *49*, 71-79. doi: 10.1016/j.childyouth.2015.01.003

Çalik, S. U., Pekel, H. A., & Aydos, L. (2018). A study of effects of kids' athletics exercises on academic achievement and self-esteem. *Universal Journal of Educational Research, 6*(8), 1667-1674. doi: 10.13189/ujer.2018.060806

Çaman, Ö. K., & Özcebe, H. (2011). Adolescents living in orphanages in Ankara: psychological symptoms, level of physical activity, and associated factors. *Turkish Journal of Psychiatry*, *22*(2).

Çelebi, M., Alkurt, S. Ö., Mirzeoğlu, D., & Şemşek, S. (2005). Evaluation of the Social Impart of Recreational Sports Activities on Orphan Turkish Girls' Attitudes. *Bolu Abant İzzet Baysal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *2*(11), 61-68. doi: 10.11616/AbantSbe.142

Creswell, J. W., & Creswell, J. D. (2019). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Culver, K. A., Whetten, K., Boyd, D. L., & O'Donnell, K. (2015). Yoga to reduce trauma-related distress and emotional and behavioral difficulties among children living in orphanages in Haiti: A pilot study. *The Journal of Alternative and Complementary Medicine*, *21*(9), 539-545. doi: 10.1089/acm.2015.0017

D'Andrea, W., Bergholz, L., Fortunato, A., & Spinazzola, J. (2013). Play to the whistle: A pilot investigation of a sports-based intervention for traumatized girls in residential treatment. *Journal of family violence*, *28*(7), 739-749. doi: 10.1007/s10896-013-9533-x

Dagkas, S., & Stathi, A. (2007). Exploring social and environmental factors affecting adolescents' participation in physical activity. *European Physical Education Review*, *13*(3), 369-384. doi: 10.1177/1356336X07081800

Farmer, E., Papadopoulos, N., Emonson, C., Fuelscher, I., Pesce, C., McGillivray, J., ... & Rinehart, N. (2020). A preliminary investigation of the relationship between motivation for physical activity and emotional and behavioural difficulties in children aged 8–12 years: The role of autonomous motivation. *International Journal of Environmental Research and Public Health*, *17*(15), 5584. doi:10.3390/ijerph17155584 w

Fore, H. H. (2020). A wake-up call: COVID-19 and its impact on children's health and wellbeing. *The Lancet Global Health*, *8*(7), e861-e862. doi: 10.1016/S2214-109X(20)30238-2

Gentile, D. A., & Anderson, C. A. (2006). Video games. *Encyclopedia of human development*, *3*(8), 1303-1307.

Georgiev, G., & Gontarev, S. (2019). Impact of physical activity on the aggressiveness, deviant behavior and self-esteem with school children aged 11-15. *Journal of Anthropology of Sport and Physical Education*, *3*(4), 21-25. doi: 10.26773/jaspe.191005

Ginieri-Coccossis, M., Rotsika, V., Skevington, S., Papaevangelou, S., Malliori, M., Tomaras, V., & Kokkevi, A. (2013). Quality of life in newly diagnosed children with specific learning disabilities (SpLD) and differences from typically developing children: a study of child and parent reports. *Child: care, health and development*, *39*(4), 581-591. doi: 10.1111/j.1365-2214.2012.01369.x

Hanrahan, S. J. (2005). Using psychological skills training from sport psychology to enhance the life satisfaction of adolescent Mexican orphans. *Athletic Insight*, *7*(3), 7-13.

Heinrich, L. M., & Gullone, E. (2006). The clinical significance of loneliness: A literature review. *Clinical psychology review*, *26*(6), 695-718. doi: 10.1016/j.cpr.2006.04.002

Hyndman, B., Benson, A. C., Lester, L., & Telford, A. (2017). Is there a relationship between primary school children's enjoyment of recess physical activities and health-related quality of life? A cross-sectional exploratory study. *Health Promotion Journal of Australia*, *28*(1), 37-43. doi: 10.1071/HE15128

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, *33*(7), 14-26. doi: 10.3102/0013189X033007014

Kalyva, P. (2016). Psycho-koinoniki symperifora kai diaprosopikes dexiotites se paidia pou zoun se idrymata. [Psycho-social behavior and interpersonal skills in children living in institutions.]. (Doctoral dissertation, National and Kapodistrian University of Athens. School of Philosophy. Department of Psychology). Retrieved from https://www.didaktorika.gr

Kearns, A., Whitley, E., Tannahill, C., & Ellaway, A. (2015). Loneliness, social relations and health and well-being in deprived communities. *Psychology, health & medicine*, *20*(3), 332-344. doi: 10.1080/13548506.2014.940354

Kiambi, E. G., & Mugambi, M. M. (2017). Factors influencing performance of orphans and vulnerable children projects in Imenti North Sub county, Meru country, Kenya. *International Academic Journal of Information Sciences and Project Management*, *2*(1), 179-196.

Kiss, E., Kapornai, K., Baji, I., Mayer, L., & Vetró, Á. (2009). Assessing quality of life: mother–child agreement in depressed and non-depressed Hungarian. *European child & adolescent psychiatry*, *18*(5), 265-273. doi: 10.1007/s00787-008-0727-3

Kolayiş, H., Sarı, İ., Soyer, F., & Gürhan, L. (2011). Effect of the physical activities on orphans' anxiety and self esteem. *Anxiety*, *2*(0.019).

Konijn, C., Admiraal, S., Baart, J., van Rooij, F., Stams, G. J., Colonnesi, C., ... & Assink, M. (2019). Foster care placement instability: A meta-analytic review. *Children and Youth Services Review*, *96*, 483-499. doi: 10.1016/j.childyouth.2018.12.002

Leslie, L. K., James, S., Monn, A., Kauten, M. C., Zhang, J., & Aarons, G. (2010). Health-risk behaviors in young adolescents in the child welfare system. *Journal of Adolescent Health*, *47*(1), 26-34. doi:10.1016/j.jadohealth.2009.12.032

Link, B. G., & Phelan, J. C. (2001). Conceptualizing stigma. *Annual review of Sociology*, *27*(1), 363-385.

Lyons, J. S., Uziel-Miller, N. D., Reyes, F., & Sokol, P. T. (2000). Strengths of children and adolescents in residential settings: Prevalence and associations with psychopathology and discharge placement. *Journal of*

the American Academy of Child & Adolescent Psychiatry, 39(2), 176-181. doi: 10.1097/00004583-200002000-00017

Macdonald, D., Rodger, S., Ziviani, J., Jenkins, D., Batch, J., & Jones, J. (2004). Physical activity as a dimension of family life for lower primary school children. *Sport, Education and Society, 9*(3), 307-325. doi: 10.1080/1357332041233130241 2

Menzies-Lyth, I. M. (1985). The development of the self in children in institutions. *Journal of Child Psychotherapy, 11*(2), 49-64. doi: 10.1080/00754178508254774

Moati, N. A. A. (2014). Effect of a motor physical program on psychologically personal social coordination and the sense of loneliness in children deprived of family care. *Interaction, 7*, 294. doi: 10.21608/jass.2014.84767

Orben, A., Tomova, L., & Blakemore, S. J. (2020). The effects of social deprivation on adolescent development and mental health. *The Lancet Child & Adolescent Health, 4*(8), 634-640. doi: 10.1016/S2352-4642(20)30186-3

Purohit, S. P., & Pradhan, B. (2017). Effect of yoga program on executive functions of adolescents dwelling in an orphan home: A randomized controlled study. *Journal of traditional and complementary medicine, 7*(1), 99-105. doi: 10.1016/j.jtcme.2016.03.001

Purohit, S. P., Pradhan, B., & Nagendra, H. R. (2016a). Effect of yoga on EUROFIT physical fitness parameters on adolescents dwelling in an orphan home: A randomized control study. *Vulnerable Children and Youth Studies, 11*(1), 33-46. doi: 10.1080/17450128.2016.1139764

Purohit, S. P., Pradhan, B., & Nagendra, H. R. (2016b). Yoga as a preventive therapy for loneliness in orphan adolescents. *Indian Journal of Health & Wellbeing, 7*(1).

Purohit, S. P., Pradhan, B., Mohanty, S., & Nagendra, H. R. (2015). Effect of yoga program on minimum muscular fitness of orphan adolescents by using kraus-weber test: A randomized wait-list controlled study. *Indian Journal of Positive Psychology, 6*(4), 389.

Quarmby, T. (2014). Sport and physical activity in the lives of looked-after children: A 'hidden group'in research, policy and practice. *Sport, education and society, 19*(7), 944-958. doi: 10.1080/13573322.2013.860894

Ramadan Bekhit, A. (2014). The Effect of the Educational Program of Basketball on the Skills Variables and Reducing Behavioral Deviations of Orphans Children. *Journal of Applied Sports Science, 4*(3), 122-126. doi: 10.21608/jass.2014.84762

Ravens-Sieberer, U., & Bullinger, M. (2000). Questionnaire for measuring health related quality of life in children and adolescents. Revised Version. *Recuperado de: http://kindl. org/cms/wpcontent/uploads/2009/11/ManEnglish. pdf.*

Reid Chassiakos, Y. L., Radesky, J., Christakis, D., Moreno, M. A., Cross, C. (2016). Council on Communications and Media. Children and adolescents and digital media. *Pediatrics, 138*(5), 25-93. doi: 10.1542/peds.2016-2593

Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M^2: Media in the lives of 8 to 18-year-olds*. Henry J. Kaiser Family Foundation.

Rotsika, V., Coccossis, M., Vlassopoulos, M., Papaeleftheriou, E., Sakellariou, K., Anagnostopoulos, D. C., ... & Skevington, S. (2011). Does the subjective quality of life of children with specific learning disabilities (SpLD) agree with their parents' proxy reports?. *Quality of Life Research, 20*(8), 1271-1278.

Rotsika, V., Vlassopoulos, M., Kokkevi, A., Fragkaki, I., Anagnostopoulos, D. C., Lazaratou, H., & Ginieri Coccossis, M. (2016). Comparing immigrant children with native Greek in self-reported-Quality of Life. *Psychiatriki, 27*(1), 37-43.

Tadesse, S., Dereje, F., & Belay, M. (2014). Psychosocial wellbeing of orphan and vulnerable children at orphanages in Gondar Town, North West Ethiopia. *Journal of Public Health and Epidemiology*, *6*(10), 293-301. doi: 10.5897/JPHE2014.0648

Smith, A. L. (2003). Peer relationships in physical activity contexts: A road less traveled in youth sport and exercise psychology research. *Psychology of sport and Exercise, 4*(1), 25-39. doi: 10.1016/S1469-0292(02)00015-8

Smyke, A. T., Dumitrescu, A., & Zeanah, C. H. (2002). Attachment disturbances in young children. I: The continuum of caretaking casualty. *Journal of the American Academy of Child & Adolescent Psychiatry*, *41*(8), 972-982. doi: 10.1097/00004583-200208000-00016

Soenens, B., & Vansteenkiste, M. (2010). A theoretical upgrade of the concept of parental psychological control: Proposing new insights on the basis of self-determination theory. *Developmental Review*, *30*(1), 74-99. doi: 10.1016/j.dr.2009.11.001

Tarullo, A. R., Bruce, J., & Gunnar, M. R. (2007). False belief and emotion understanding in post-institutionalized children. *Social Development, 16*(1), 57-78. doi: 10.1111/j.1467-9507.2007.00372.x

Tümkaya, S. (2005). Ailesi yaninda ve yetistirme yurdunda kalan ergenlerin umutsuzluk duzeylerinin karsilastirilmasi. *Journal of Turkish Educational Sciences, 3*(4), 445-459.

Vidali, L. E., Vidalis, A., Ravens-Sieberer, U., & Bullinger, M. (2001). H elliniki ekdosi tou erotimatologiou KINDL®. [The Greek version of the KINDL® questionnaire.]. *Ippokratia, 5* (3), 124-135.

Whoqol Group. (1995). The World Health Organization quality of life assessment (Whoqol): position paper from the World Health Organization. *Social Science & Medicine, 41*(10), 1403-1409. doi: 10.1016/0277-9536(95)00112-K

World Health Organization. (2015). Measuring quality of life. 1997. https://www.who.int/tools/whoqol

UTICAJ PROGRAMA FIZIČKE AKTIVNOSTI NA POBOLJŠANJE KVALITETA ŽIVOTA MLADIH KOJI ŽIVE U DOMU ZA NEZBRINUTU DECU: STUDIJA MEŠOVITIH METODA

Smatra se da fizička aktivnost ima pozitivan uticaj na kvalitet života mladih koji žive u institucijama za nezbrinutu decu. Međutim, osobe koje deca smatraju značajnim mogu uticati na njihovu percepciju fizičke aktivnosti. Cilj ovog istraživanja bio je da se (a) istraži uticaj programa fizičke aktivnosti na kvalitet života mladih ljudi koji žive u instituciji za nezbrinutu decu i (b) da se utvrdi uloga koju odnosi formirani u ovoj instituciji igraju u postizanju ciljeva samog programa. Za potrebe analize koristili smo studiju mešovitih metoda. Istraživanje je sprovedeno u domu za nezbrinutu decu u mestu Atika u Grčkoj. Dvanaest od 13 dečaka smeštenih u domu (Mage= 13.08 ± 2.43 years) učestvovalo je u programu fizičke aktivnosti u trajanju od deset nedelja, koji se sprovodio u samoj instituciji. Dečaci i jedan vaspitač popunili su KINDL® upitnik pre i nakon implementacije programa. Kvalitativni podaci prikupljani su obzervacijom i tokom polu-strukturisanih intervjua sa dečacima kao i sa šestoro njihovih vaspitača. Rezultati pokazuju da je nivo kvaliteta njihovog života nizak; a uočen je i statistički značajan pad u ukupnim KINDL® rezultatima (p= .033) i rezultatima Skale emotivnog zadovoljstva (p= .013). Rezultati su ukazali na to da su deca iz doma sporadično učestvovala u program fizičke aktivnosti, iako su tvrdili da im je učestvovanje bilo važno. Faktori odnosa između pojedinaca i između grupa pojedinaca u domu identifikovani su kao prepreka za učešće u programu fizičke aktivnosti. Vrlo je verovatno da život u instituciji dovodi do značajnog pada kvaliteta života mladih ljudi koji se ne može prevazići njihovim učešćem u programu fizičke aktivnosti.

Ključne reči: *sport, deca iz doma za nezbrinutu decu, dobrobit, zdravlje*

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

796/799

FACTA Universitatis. Series, Physical Education and Sport / University of Niš ; editor-in-chief Zoran Milanović. - [Štampano izd.]. - Vol. 1, no. 7 (2000)- . - Niš : University of Niš, 2000- (Niš : Atlantis). - 24 cm

Tri puta godišnje. - Je nastavak: Facta Universitatis. = ISSN 0354-4745. - Drugo izdanje na drugom medijumu: Facta Universitatis. Series: Physical Education and Sport (Online) = ISSN 2406-0496
ISSN 1451-740X = Facta Universitatis. Series: Physical Education and Sport
COBISS.SR-ID 113549324