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Original research article

VARIATIONS OF MUSCULAR STRENGTH AND POWER IN MALE HANDBALL PLAYERS DURING AN ENTIRE SEASON

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Abstract. *Competition performance in handball depends on various individual skills and interaction with teammates. Technical and tactical efficiency are probably the most influential factors, while physical characteristics represent the prerequisite to attaining high level of competition performance. The purpose of the study was to determine the variations of muscular strength and power in male handball players during an entire season. The study was carried out on a sample of14 male handball players, members of the handball club, the participant of the Serbian male handball league during the 2014/2015 season. Measurements were taken four times during the period between the 6th and the 18th round of the handball league. The investigation protocol consisted of anthropometric measurements, determinations of the one-repetition maximum and assessments of muscular power. The obtained data indicate that no significant variations of muscular strength and power in male handball players occur during a competitive season. Besides, this study showed that players who compete in the Serbian male handball league have similar anthropometric characteristics, but significantly lower values of muscular strength and power when compared to top level European male handball players, and that it is necessary to pay much more attention to resistance training during the preparation period. Low values of the first measurement, which was the closest to the preparation period, are the probable reason for the non-existence of major variations during the competitive season.*

Key words: *history, measuring instrument, scientific journal, research design, methodology.*

INTRODUCTION

Handball is one of the fastest team sports, characterized by consecutive jumps, sprinting, changes of direction, body contact and technically specific movements which

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represent responses to various tactical situations (Karcher & Buchheit, 2014). However, it is very difficult to describe the game of handball and determine the factors that influence a competition performance because handball is a complex team game influenced by a vast number of factors and their mutual interaction (Wagner, Finkenzeller, Wurth, & von Duvillard, 2014). Male handball players have to coordinate their movements while running, jumping, changing direction and pushing with the execution of specific technical movements, such as throwing, passing, catching and blocking. Competition performance in handball depends on various individual skills and interaction with teammates. Technical and tactical efficiency are probably the most influential factors, while physical characteristics represent the prerequisite to attaining a high level of competition performance (Povoas et al., 2012).

The components that have to be accentuated in order to achieve the objective are defined during the training phases preceding the competition. The workload issue during the physical preparation phase in sports is everything but simple. For this reason all coaches should look for the optimal balance between the load components, one for each new phase of competition or physical preparation in particular. It is especially important for the coach to have knowledge of the volume of the load, its specific features and the dosage of the load during a competition and training process (Koprivica, 2002). Former studies indicate that muscular strength and power of the upper and lower extremities are important for the increase of the performance of male handball players, as well as for the prevention of the rapid decrease in the performance during the final stages of a game (Wallace & Cardinale, 1997). Gorostiaga, Granados, Ibanez & Izquierdo (2005) pointed out that higher values of muscular strength and power provide obvious advantages when it comes to maintaining a high level of muscular contractions during the execution of specific movements throughout the game of handball. In order to avoid potential negative effects of muscular strength and power training, it is currently considered that this kind of training should be adjusted to the specific requirements related to a playing position on the field.

The purpose of the study was to determine the variations of muscular strength and power in male handball players during an entire season.

THE METHOD

The study was carried out on a sample of 14 male handball players, members of a handball club competing in the Serbian male handball league–SRLS during the 2014/2015 season. Measurements were taken four times during the period between the 6th and the 18th round of the SRLS handball league.

The experimental research programme was established as the working plan and program of the studied male handball club during the 2014/2015 competitive season of the SRLS handball league, where the overall training load was classified as the amount of time each participant spent performing any of the 11 activities (Gorostiaga, Granados, Ibanez, Gonzales-Badillo & Izquierdo, 2006). This way, it was determined that each participant spent 100.4 minutes or 15.2 % of his total weekly training load training with external load (free weights and/or machines). In addition, it was also determined that each participant spent 37.9 minutes or 5.7 % of his total weekly training load performing strength training (running up the hill or up the stairs, consecutive jumps, medicine ball throwing).

All of the participants had volunteered to take part in the study. They were informed regarding the main purpose of the study, procedures, and the experimental risks, and they all signed an informed consent document prior to the study. The procedures presented were in accordance with the ethical standards regarding experiments involving humans. The Human Investigation Committee of the Faculty of Sport and Physical Education in Nis approved the study. The standard medical screening was performed before the study. None of the participants showed any evidence of recent injury in their anamnesis or clinical report. All the participants were instructed not to engage in exhausting exercise (except regular handball training) for a period of 24 hours prior to the testing. They were warned to refrain from eating or drinking energy or caffeine drinks two hours prior to the testing. The participants were allowed to drink non-caffeinated liquids *ad libitum* before the testing. All the participants had considerable experience in performing chest press and squat exercises, taking into account that those are the most frequently used resistance training exercises.

All the measurements took place during the morning hours, at approximately the same time, according to protocol and in accordance with the recommendations of the manufacturer of the apparatus and equipment that was used. The measurements were taken by experts with prior experience in the above mentioned kind of measuring procedures.

Study setting

All of the testing sessions took place in a gym. Measurement of body height was performed with the anthropometric instrument GPM model 101 (*GPM GmbH Switzerland*). For the measurement of the body weight and the body fat percentage of the participants, the laboratory method of bioelectrical impendence analysis was used, performed by an electronic scale *Omron BF 511* (*Omron Healthcare Co, Kyoto, Japan*). Prior to testing, the participants warmed up for approximately 10−15 minutes of submaximal intensity aerobic activity on stationary bikes and/or step machines and short bouts of dynamic muscle stretching.

Testing protocol

1RM Testing. The participants underwent a one-repetition maximum (1RM) test on a flat bench. Prior to each 1RM test, two warm-up sets were performed: first with eight repetitions at approximately 50% of 1RM, and then with four repetitions at approximately 70% 1RM. Next, single attempts with increasingly heavier resistance of at least 2.5 kg were performed until each participant reached the maximum weight that he could lift once using the correct technique. A 3-minute rest period was given between each lift. The 1RM was achieved within 3−6 attempts (Kraemer & Fry, 1995). For safety purposes, two spotters were present at all times. The correct chest press technique involved lowering the bar in a controlled manner until it lightly touched the chest, after which the bar was lifted back to the initial position with elbows fully extended. Careful attention was paid in order to ensure that the bar did not bounce off the chest. No compensatory motion was allowed during the chest press movement. Barbell squats on the gym floor were performed from full extension to a knee angle of 90° while the participant held the barbell on his back. The participants were monitored in order to ensure that they lifted the barbell without significant deviation from a line perpendicular to the floor. The tempo of each 1RM

attempt was not controlled so that as long as good technique was adhered to, the participants could take as long as required to complete the lift.

Muscular power for each repetition was measured by means of the *Fitrodyne Premium dynamometer* (*Fitronic, Bratislava, Slovakia*) according to the suggested protocol and under stable conditions. The validity and reliability of the device was previously confirmed (Jennings, Viljoen, Durandt, & Lambert, 2005). During each of the sessions, the participants were instructed to accelerate the barbell as fast as possible during the entire range of motion, during which the peak power and velocity of movement were measured by means of a computer-interfaced Fitrodyne attached to the barbell via a tether. All of the data were analyzed, based on Newton's second law, by using the appropriate software (*Fitronic, Bratislava, Slovakia*) in addition to the dynamometer.

Statistical analyses

Descriptive statistics were calculated for all the experimental data as mean values and SD. The Kolmogorov Smirnov test of normality was performed on all the variables, and all the data were normally distributed. The effects of the training programs on 1RM and muscle power were tested with the analyses of variance (ANOVA), and if significant interactions were detected, a Bonferroni post hoc test was used. The level of statistical significance was set at $P<0.05$. The data were described as means ± standard deviation (SD). All the statistical analyses were performed using the SPSS version 16.0 software (SPSS Inc., Chicago, IL).

RESULTS

The Kolmogorov-Smirnov tests revealed the normality of the data. All the examined variables showed no significant changes during testing at four different periods during the competitive season.

Table 1 The variations of weight and body fat during an entire season (means±SD)

Variables / Testing period	1st	2nd	3rd	4th	F	Sig.
Age (years)	19,79±2,08					
Height (cm)	188,74±6,15					
Weight (kg)	88,79±10,42	88,14±9,59	88,87±7,02	88,33±8,96	,021	,996
Body fat (%)	20,13± 4,02	19,81±3,72	18,32±2,11	18,86±2,18	1,005	,398

Table 2 The variations of a one-repetition maximum (1RM) test during an entire season (means±SD).

Variables / Testing period	1st	2nd	3rd	4th	F	Sig.
Bench press (kg)	87,11±4,09	87,48±3,99	87,7±3,41	87,5±4,75	,051	,985
Barbell squats (kg)	100,51±5,14	101,6±5,23	102,01±6,37	101,14±6,72	,166	,919

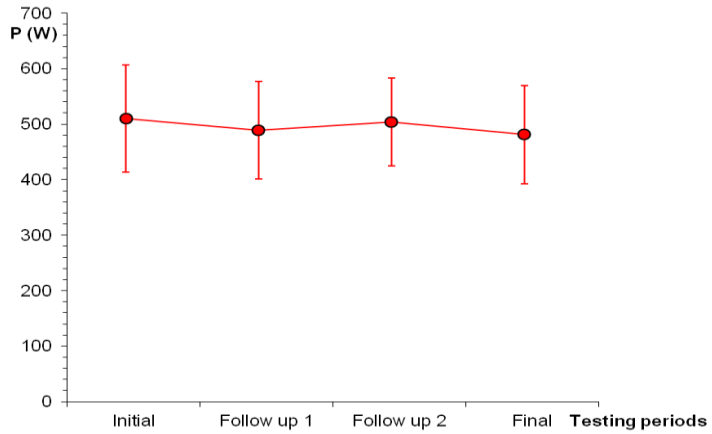

Fig. 1 The variations of bench press peak power during an entire season.

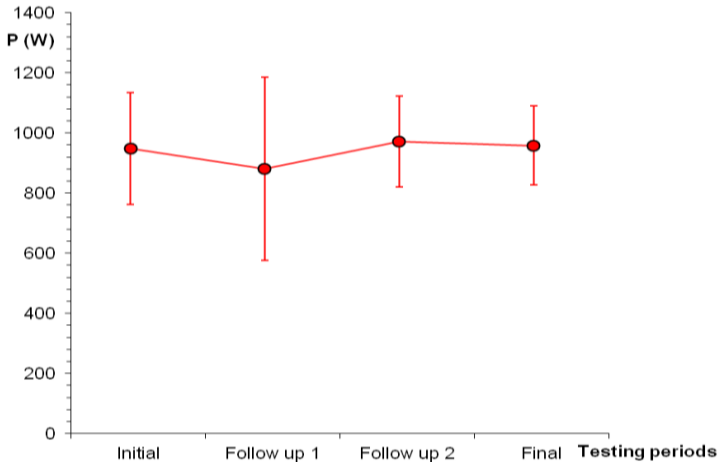

Fig. 2 The variations of squat peak power during an entire season.

DISCUSSION

Variations of muscular strength and power in male handball players during an entire season were monitored during the conducted study. Defining the duration of certain levels of loads during the game of handball and the requirements which male handball player has to comply with are the basis for the assessment of the optimal level of motor and physiological parameters in male handball players. However, this is not possible because of the complexity and unpredictability of a handball match. We consider that monitoring of the training load and certain parameters in male handball players is the approach which is closest to the optimal one.

The analysis of the obtained data indicated that there were no statistically significant differences in the percentage of body weight and in body fat (Table 1), which excluded

the analysis of their influence on the measured values of muscular strength and power. The body height and weight of the participants, members of this Serbian handball club, were very similar to the values of the participants from the study which involved 176 Norwegian male first league handball players, members of the national team and (Haugen, Tønnessen & Seiler, 2014).

The statistical analysis showed that there were no important differences in the obtained values of muscular strength between the conducted measurements(Table 2). The obtained mean values of the chest press exercise with 1 one-repetition maximum were approximate to the values obtained in amateur players (82.5 ± 14.8 kg), but they were also significantly lower than in top level players (106.9 ± 11.6 kg), according to the data from the study that proved the existence of significant differences among male handball players from different levels of competition (Gorostiaga et al., 2005).

In the study of Gorostiaga et al., (2006), the obtained value of the chest press exercise with 1 one-repetition maximum increased by 2 % during the period between the beginning of the preparation phase and the beginning of the first phase of the competition (from 104.8 ± 15.6 kg to 106.9 ± 11.6 kg). This increase remained quite stable until the end of the first phase of the competition. However, the indicators of the explosive power of lower and upper extremities remained unaltered during the entire season. The study which involved 176 Norwegian male handball players indicated that the values of 1RM obtained by means of testing the bench press were distributed in the range of 100kg and 110kg (Haugen et al., 2014). It was also determined that pivots had the highest values, which could be explained by the fact that their specific playing position on the field requires the most frequent physical contacts during a game and the specificity of their physique involving a well-developed chest (Karcher et al., 2014). The above mentioned studies clearly point out that in physical contact sports, such as handball, the value of the maximum muscular strength significantly influences competition performance. For this reason we consider that the participants in our study had relatively low values of muscular strength, and that it is necessary to pay much study had relatively low values of muscular strength, and that it is necessary to pay much more attention to the resistance training during the preparation period. Low values of the first measurement, which was the closest to the preparation period, are the probable reason for the non-existence of major variations during the competitive season.

Similar to the chest press values, the values obtained during squat exercises with one-repetition maximum (Table 2) were significantly lower than the ones of the top level male handball players. The improvement in the maximum muscular power and the vertical jump height were noted in the study including 16 professional male handball players, engaged during 12 weeks of training with external load based on the following exercises: the chest press, half-squat and consecutive vertical jump with load (Marques & Gonzalez-Badillo, 2006). The value of the squat exercises with one-repetition maximum increased from 93.5 ± 13.9 kg to 122.2 ± 21.6 kg after six weeks of the program, and 134.1 ± 19.4 kg after 12 weeks. In the study involving Norwegian male handball players, the values of 1RM obtained by testing squat exercises ranged from 125kg and 130kg, which indicates that high competition level in handball requires high values of muscular power of the lower extremities. An interesting fact is that differences among various playing positions were not determined, so wing players, who have the lowest body weight, obtained higher values of relative power when compared to pivots and goalkeepers (Haugen et al., 2014).

The analysis of the obtained data indicated that there were no statistically significant differences in muscular power during the competitive season. All three values of muscular

power determined by the chest-press (Figure 1) were lower than the values of the first measurement, but the difference was not statistically significant (F= 0,324, Sig.=0,808). The values of muscular power determined by squat testing were lower during the second measurement and also was not statistically significant (F=0,543, Sig.=0,655). Considering the previously analyzed muscular strength data, we can indirectly conclude that there was no increase in the movement speed, namely neuromuscular execution, so any bigger differences were not present. Taking into consideration the applied measurement procedure and the non-existence of similar research data on male handball players, it was not possible to compare the obtained values to any other.

CONCLUSION

The obtained data indicate that no significant variations of muscular strength and power in male handball players occur during a competitive season. Besides, this study showed that players who compete in the Serbian male handball league have similar anthropometric characteristics, but significantly lower values of muscular strength and power when compared to top level European male handball players. The targeted studies that were conducted during the last couple of years undoubtedly indicated the necessity of applying an individual approach, while respecting the specificity of each playing position on the field, in order to create an optimal power training program. This kind of approach is necessary for both professional players and for the development of the full potential of talented young players. We consider that this kind of targeted scientific researches should precisely determine the influence of various factors on the competition performance of male handball players and in this way contribute to the increase of the quality of the work of coaches. Scientific studies should also develop specific measuring and testing methods that are most useful in terms of evaluation of the effects of training in handball.

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UNUTAR SEZONSKE VARIJACIJE MIŠIĆNE SILE I SNAGE KOD RUKOMETAŠA

Takmičarski učinak u rukometu zavisi od različitih individualnih veština i interakcije sa suigračima u timu. Tehnička i taktička efikasnost su verovatno faktori od najvećeg uticaja, dok su fizičke karakteristike neophodni preduslov za visok takmičarski učinak. Cilj sprovedenog istraživanja bio je da se utvrde varijacije mišićne sile i snage tokom takmičarske sezone. Istraživanje je sprovedeno sa 14 rukometaša muškog rukomentnog kluba, učesnika Super rukometne lige Srbije u sezoni 2014/2015. Merenja su izvršena ukupno četiri puta, u perodu između šestog i 18. kola rukometne lige. Protokol istraživanja se sastojao od antropometrijskih merenja, određivanja vrednosti jednog maksimalnog ponavljaja i procene mišićne snage. Dobijeni podaci pokazuju da kod rukometaša ne dolazi do značajnih varijacija mišićne sile i snage tokom takmičarske sezone. Pored toga, ovo istraživanje je pokazalo da igrači koji se takmiče u Super rukometnoj ligi Srbije imaju slične antropometrijske karakteristike, ali značajno manje vrednosti mišićne sile i snage u odnosu na vrhunske evropske rukometaše, te da je neophodno da se tokom pripremnog perioda mnogo veća pažnja usmeri na treninge sa spoljašnjim opterećenjem.Verovatno je da su niske vrednosti na prvom merenju, koje je bilo najbliže pripremnom periodu, uzrokovale da nije bilo većih varijacija tokom takmičarske sezone.

Ključne reči: *rukomet, mišićna sila, mišićna snaga, sezonske varijacije.*