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Review scientific paper

FACTORS OF INFLUENCE ON PERFORMANCE OF COUNTERMOVEMENT JUMP

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Abstract: Countermovement jump is an exercise that develops leg muscle power, the efficiency of using the stretch-shortening cycle, and the jump height. Numerous factors influence countermovement jump height. This paper analyses the most important external and internal factors. The aim of this paper was to describe and explain the influence of external factors on countermovement jump height. A comparative analytical method is used to compare and comment on the results of scientific research. The following external factors are considered in this paper: type of training, performance technique, and instructions, and internal factors: age, sex, body composition. The results of the paper showed that among external factors, the greatest influence is noted in the performance technique factor, while among internal factors there is a contingent influence of age, sex, and body composition factors on countermovement jump height. The results of the paper contribute to the understanding of the nature of the influence of external and internal factors that affect countermovement jump height, which can improve scientific - professional work in sports.

Keywords: *type of training, performance technique, sex, age*

INTRODUCTION

Motor abilities are inborn qualities, which can be developed and assessed by applying appropriate exercises and methods. Regular monitoring of the levels

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of motor abilities and their development contributes to the quality of scientific and professional work. Countermovement jump (CMJ) is used to develop and assess power, fatigue, and progress in athletes' abilities. Countermovement jump implies a stretching and shortening cycle (SSC), which enables the manifestation of muscular force in the shortest possible time. Countermovement jump height can be measured in various ways, such as the reach height of the jump, via contact mats, force plates, and other types of technology. Various factors that affect the height of countermovement jump draw the attention of researchers.

Factors can exert an influence of different degrees of intensity: small, moderate, and big influence and they can also fully influence and thus completely determine the observed phenomenon. Factors can have a contingent influence on a complex phenomenon, where one factor can have a greater or lesser impact on the observed phenomenon, depending on the interaction with other influencing factors (e.g. nutrition of athletes in interaction with training, recovery, psychological state, club relations, and teammates, etc.).

Factors in scientific research are frequently divided in external and internal. According to the classification of factors in drop jump in the Matić study (Matić, 2016), a similar classification of factors was defined in this study for countermovement jump. This division was made according to the affiliation criterion of external factors, i.e. objective environment or internal, i.e. subjective environment. In this paper, the most important external factors are analysed: type of training, performance technique, and instructions, and internal factors: age, sex, body composition.

The basic problem question in the paper is complex and reads: Which factors have an impact on countermovement jump height, as well as which factors have the greatest influence, and is there a contingent effect between them? The subject of this paper consists of external and internal factors, countermovement jump, and the influence of factors on countermovement jump height. The aim of this paper is to describe and explain the influence of external and internal factors on countermovement jump height, as well as to determine which factors have the greatest influence and whether there is a combined influence between them.

METHOD

In this paper the authors used comparative analytical method, which compares and comments on the results of scientific research. By searching the databases PubMed, Journal of Strength and Conditioning Research, Google Scholar, and keywords: *“countermovement jump height”, “plyometric”, “plyometric training”, “instructions”, “technique”, “sex”, “age”, “body composition*”, papers corresponding to the topic of this paper were selected and analysed. Only original scientific papers were searched and analysed.

RESULTS AND DISCUSSION

EXTERNAL FACTORS THAT INFLUENCE COUNTERMOVEMENT JUMP HEIGHT

Training type

In sports training, various training methods are used in order to improve sports abilities, such as classical weightlifting, Olympic lifting, bodyweight training (body weight as resistance), plyometric method, ballistic method, and others. Depending on the specificity of the sport and the requirements of the sports branches, appropriate methods will be applied to achieve the desired adaptations of an athlete's organism. Monitoring the level of abilities of athletes provides insight into the effectiveness of the applied training methods and enables better management of the training process. To this end, Moore et al. (Moore, Hickey, Reiser, 2005) examined how different training methods affect a player's abilities. During 12 weeks, participants with an average age of 20 and 13 years of training experience were divided into the Olympic weightlifting group - group 1 (n=8) and the plyometric group - group 2 (n=7). Exercises performed within these methods are considered to be fast movements, such as sprints, throws, hops, jumps, and other movements. It is important to note that the participants had very little experience in training with load (gym training and plyometric exercises) and that the groups did not differ significantly in terms of anthropometric values of body height and body weight. Both groups conducted a training program three times a week, where in each training session for the last 30 minutes they implemented the method of classical weightlifting, for which the performance movements are slower than with the mentioned methods. Table 1 shows the results of countermovement jump height.

Table 1. *Results of average values of countermovement jump height in both groups, before and after 12 weeks of training program* (Moore, Hickey & Raoul, 2005)

Test	Group	Pre-test	Post-test	Difference
Countermovement jump (cm)	Group 1	47.3	51.5	4.2
	Group 2	41.4	46.2	4.8

Measuring before the start of the program determined that the countermovement jump height in group 1 was 47.3 cm and in group 2 it amounted to 41.4 cm. The results show that both groups significantly improved their jump height after 12 weeks, while no statistically significant differences ($p>0.05$) between groups were found. Group 1 made continuous progress in jump height from the beginning of the program compared to the end of the program by 4.2 cm. The jump height in group 2 in the middle of the program decreased by 2 cm compared to the beginning of the program and then increased by 4.8 cm at the end of the program compared to the middle of the program. In absolute terms, both groups made similar progress at the end of the training program compared to the beginning. Moore et al. (2005) explains that the drop in the middle of the program in group 2 occurred due to the time needed to learn how to perform plyometric exercises correctly, as well as the time needed for the organism to recover from the new loads. Also, in the second half of the program, plyometric exercises of higher intensity were used, which contributed to a higher jump height at the end of the program.

The study by Moore et al. (2005) showed that the mentioned training methods similarly contributed to the higher jumping height for the period of 12 weeks. These findings are useful for athletes who are just beginning to compete because Olympic weightlifting requires special equipment, and on the other side, plyometric training can be performed outdoors or in a poorly equipped indoor space.

The plyometric method, whose main tools are jumps, is an effective way to develop explosive muscular force. The characteristic of this method is that it is performed without load or with very little additional load, and the intensity of the load can be dosed with different jumping conditions, such as: varying the height of jumps and drop heights, use of different equipment, hurdles, boxes, running on one leg, etc. To examine the impact of plyometric training on speed, explosive force, and kick speed in women's soccer, Ozbar et al. (Ozbar, 2015) conducted a 10-week study. Participants (n=20) of the first Turkish league, aged 19, with experience of at least five years of training and at least three years of plyometric training, were equally divided into an experimental group, which conducted plyometric training twice a week and a control group, which did not conduct plyometric training. The groups were homogeneous in terms of training experience and morphological characteristics: body height, body mass, and body mass index (BMI). The training program conducted by the experimental group consisted of various exercises of hops, jumps, and sprints, which were performed over hurdles that were 40 to 60 cm high. The results of the study are shown in Table 2.

Table 2. *Results of average values of countermovement jump height before and after training program for 10 weeks for experimental and control group* (Ozbar, 2015)

Test	Group	Pre-test	Post-test	Difference
Countermovement jump (cm)	Experimental group	40.1	48.6	8.5
	Control group	39.7	42.3	2.6

By conducting measuring before the start of the program, the experimental group achieved a countermovement jump height of 40.1 cm, and after the program the height was 48.6 cm, which is a difference of 8.5 cm. That is 5.9 cm more than the control group, which achieved an improvement of 2.6 cm. Comparing the studies, it can be seen that in the Moore et al. (2005) study, the participants who performed the Olympic lifting method achieved a lower countermovement jump height of 4.27 cm, as well as those who performed the plyometric method by 3.7 cm compared to the participants in Ozbar's study (2015) who conducted only the plyometric method. In absolute terms, the factor type of training in a moderate extent of 8.5 cm contributes to the increase of countermovement jump height.

Performance technique

Countermovement jump is performed as one continuous movement, starting from an upright position from which a quick squat is performed, which implies flexion in the ankle joints, knee joints, and hips. Immediately after the squat, an extension is performed in all three mentioned joints. Countermovement jump can be performed without swinging the arms (hands are held at the nape of the neck or on the hips) or with swinging the arms. In everyday and sports activities, jumps are usually performed with a quick swing of the arms together with the movement of the legs, which results in a higher jump height. In Akl's study (Akl, 2013), the aim was to compare the biomechanical parameters between countermovement jump with arm swing and without arm swing and to investigate how arm swing can increase the height of the jump. The participants were highly trained volleyball players who performed countermovement jump with and without swinging the arms.

The results of Akl's study (2013) based on the observation of the movement of the centre of gravity of the body show that the participants achieved an average jump height of 61 cm with arm swing, while without arm swing they achieved a jump height of 48 cm, which makes a significant difference of 13 cm. In addition, higher values of maximum force, speed, kinetic and potential energy when separating the feet from the ground were achieved in the performance of countermovement jumps with arm swing, with a statistically significant difference ($p<0.001$) in relation to the performance of countermovement jumps without arm swing.

A somewhat newer and more complex study by Sanchez-Sixto et al. (Sánchez-Sixto, Harrison, Floría, 2018) aimed to determine how modifications to the squat depth lead to a change in jump height. The study involved 29 basketball and football players competing in regional leagues and all had previous experience in performing jumps with different squat depths. All participants performed three different squats with a squat holding their hands on their hips and with the following verbal instructions:

1. Jump with freely selected squat depth (Jump 1): "Jump as high as possible"
2. Jump with a small squat depth (Jump 2): "Jump as high as possible with smaller squat depth"
3. Jump with large squat depth (Jump 3): "Jump as high as possible with greater squat depth"

All countermovement jumps were performed on a “Force plate”, through which the squat depth and the jump heights were measured and controlled. Successful performance of jumps with small and large squat depth was when they were smaller, or larger than 5 cm than the countermovement jump with self-selected squat depth. The results of the research show that squat depth significantly affects the height of countermovement jumps, which is shown in Table 3.

Table 3. *Results of average values of countermovement jump height, observed based on movement of body weight centre* (Sánchez-Sixto, Harrison & Floría, 2018)

Test	Jump 1	Jump 2	Jump 3
Countermovement jump (cm)	48	45	50

Table 3 shows that the participants achieved the highest height on average in Jump 3 of 50 cm, with a statistically significant difference ($p<0.05$) in relation to Jump 1, which is a small difference of 2 cm and in relation to Jump 2, where the difference is slightly larger - 5 cm.

It can be concluded that the performance technique factor and the factor of instructions in the study of Sanchez-Sixto et al. (2018) act contingently, contributing to a small extent of 2 to 5 cm to the increase in jump height compared to the other two conditions for performing a countermovement jump. If the goal is to achieve maximum jump height or to manifest/develop maximum muscle power, trainers should provide instruction that will allow a large squat depth, in order to produce the desired training effects.

By comparing the studies, a difference is perceived in the influence intensity of the performance technique factor, so the participants in Akl's study (2013) achieve a 13 cm higher countermovement jump when swinging their arms, while the participants in the Sanchez-Sixto et al. study (2018) with a larger squat depth in contingent action with the factor of instructions achieve a jump higher by 3 to 5 cm. This represents a significant difference of 6 to 8 cm and thus a higher intensity of the action of the performance technique factor. In absolute terms, the performance technique factor in Akl's study (2013) largely contributes to higher countermovement jump height.

Instructions

In sports training, various instructions are used to learn movement skills and techniques, as well as to increase the efficiency of athletes' movements. It has been proven that instructions with an external focus in which attention is cantered on an object or subject have a better effect on performing motions and movements, than instructions with internal focus, in which attention lies on one's own body and body feeling in space.

In the previously mentioned study by Sanchez-Sixto et al. (2018), with the analysed factor of performance technique, the contingent effect of performance technique factor and instruction factor contributed to a 3 to 5 cm higher countermovement jump height. A more recent study by Kershner et al. (Kershner, Fry, Cabarkapa, 2019) measured acute differences in performing countermovement jump by instructing participants with external and internal focus. The instruction with the external focus was: "In these conditions, only concentrate on pushing off the surface as explosively as possible", while the instruction with internal focus was: "In these conditions, only concentrate on stretching the knees and hips as explosively as possible". All participants (n=43) had previous experience of at least six months in weight training, five years in competitive baseball, and were considered experts in performing countermovement jump. The results of the research show that the participants who performed countermovement jump with the external focus instruction achieved an average jump height of 48.0 cm, while the participants who performed the jump with internal focus instruction achieved an average jump height of 46.4 cm, which is a difference of only 1.6 cm. These results are consistent with the Talpey et al. study (Talpey, Young, Beseler, 2016), where participants who performed countermovement jump with external focus instruction achieved an average jump height of 45.9 cm, while participants who performed a jump with instruction to accentuate internal focus scored an average jump height of 44.0 cm, which represents a similar difference of 1.9 cm.

Comparing the studies, it is noticed that the participants in the study of Sanchez-Sixto et al. (2018), where there is a contingent effect of factor instructions and performance technique, achieved higher jump height compared to the studies of Kershner et al. (2019) and Talpey et al. (2016), therefore differences in intensity of factors exist. If we observe the isolated effect of the instructions factor, it has a small effect of 1.6 to 1.9 cm on increase in countermovement jump height.

INTERNAL FACTORS THAT INFLUENCE COUNTERMOVEMENT JUMP HEIGHT

Sex

There are certain differences between men and women, such as higher muscle mass by 3% in the upper part of the body in men than in women, a higher percentage of fat, especially in the thighs and hips in women, on average women are 40% to 60 % weaker than men in the upper body and 25% to 30% in the lower body. When muscle strength is expressed relative to lean body mass, sex differences do not exist, indicating inborn similar muscle qualities and motor control (Kenney, Wilmore, Costill, 2015).

A transversal study by Temfemo et al. (Temfemo, Hugues, Chardon, Mandengue, Ahmaidi, 2009) examined differences in the performance of countermovement jumps in boys (n=240) and girls (n=239) of different age. The instruction was the same for all participants: "Jump as fast as you can to reach the maximum jump height." The results of the research shown in Table 1 show higher countermovement jump heights in boys of all ages compared to girls, with statistically significant difference ($p<0.05$), except at 11 years of age.

Table 4. *Results of mean values of countermovement jump height in boys and girls aged 11 to 16*
(Temfemo, Hugues, Chardon, Mandengue & Ahmaidi, 2009)

Variables	Age	11	12	13	14	15	16
Countermovement jump height (cm)	Boys	25.3	28.9	32.5	36.9	39.9	42.9
	Girls	25.3	27.5	30.7	33.2	35.5	36.8
Body height (cm)	Boys	148.0	155.6	162.4	168.4	172.5	174.1
	Girls	149.1	156.3	159.8	163.2	163.7	164.3
Body weight (kg)	Boys	41.9	46.0	51.9	56.0	60.4	62.8
	Girls	43.0	47.7	50.9	54.6	56.9	58.1
BMI (kg/m2)	Boys	19.1	19.0	19.6	20.0	20.7	21.0
	Girls	19.3	19.5	19.9	20.6	21.2	21.5
Fat percentage (%)	Boys	15.9	14.5	16.1	17.4	17.9	18.5
	Girls	18.7	19.6	21.3	22.8	23.4	24.0
Fat-free component (kg)	Boys	35.3	39.4	43.6	46.3	49.6	51.2
	Girls	34.9	38.4	40.0	42.2	43.6	44.1
Percentage of fast twitch muscle fibres (%)	Boys	22.1	23.8	25.2	27.5	28.5	31.8
	Girls	22.1	22.3	23.5	25.9	27.1	27.6

From Table 1, it can be seen that boys achieved the highest countermovement jump height of 42.9 cm at the oldest age of 16, while girls at the same age achieved the highest countermovement jump height of 36.8 cm, which makes a significant difference between the sexes of 6.1 cm. On the other hand, it can be seen that the lowest countermovement jump height of 25.3 cm was achieved by both sexes, at the age of 11, which means that at the lowest jump height there are no differences between the sexes. Common to both sexes is a linear increase in countermovement jump height at the ages of 12 to 16. In this regard, it can be noticed that the difference in countermovement jump height between boys and girls increases linearly in favour of boys.

Comparing the highest values of countermovement jump height of 36.8 cm in girls from the study of Temfemo et al. (2009) with the highest values of countermovement jump height of 36.1 cm in boys from the study of Nikolaidis (2014), shown in Table 2, no significant difference is observed, which is 0.7 cm, at the same age of 16 years. On the other hand, by comparing the lowest achieved countermovement jump height in girls of 27.5 cm and boys of 22.80 cm (at the same age of 12 years) there is a bigger difference of 4.7 cm. The difference in countermovement jump height of these 4.7 cm can be explained by the action of body composition factor, whose variable values are: body height, body weight, and fat-free component in girls compared to boys of the same age. Also, girls achieve higher countermovement jump height by 3.2 cm (at the same age of 14). This can also be explained by the higher values of body composition variables: body height, body weight, body mass index (BMI) and fat percentage (%) in favour of girls. This may indicate that the boys in the Nikolaidis study (2014) are less biologically mature and probably less motorically developed since they achieve lower jump heights at all ages than the boys in the study of Temfemo et al. (2009). Also, it is founded that factors such as sex, age, and body composition act combined on countermovement jump height.

The sex factor in the study of Temfemo et al. (2009) in a combined action with the body composition factor (higher values of body composition variables) in favour of boys contributed to a greater manifestation of countermovement jump height in boys compared to girls by 6.1 cm. A comparison of girls from the Temfemo et al. study (2009) and boys from the Nikolaidis study (2014) showed no significant differences in the highest values in countermovement jump height at the age of 16 (common age), while a difference of 4.7 cm exists at the lowest age values of 12 years (common age), where there is also a combined effect with the factor of body composition. In absolute terms, the sex factor in action with the body composition factor and the age factor (age 12) in favor of girls has a moderate influence on increasing countermovement jump height by 4.7 cm, while at the age of 16 it has a moderate influence, increasing countermovement jump height in favour of boys by 6.1 cm.

Age

There are often differences in children's chronological and biological age, and children of the same age can be biologically more mature and stronger than their peers. Muscle strength as the ability of each person improves with increasing muscle mass that grows with age. The highest values of muscle strength in women are achieved at the age of 20, while in men they are achieved between 20 and 30 years of age (Kenney, Wilmore, Costill, 2015).

In a study by Temfemo et al. (2009), Table 4 shows that the highest countermovement jump height of 42.9 cm is achieved at the oldest age of 16 in boys. On the other hand, the lowest jump height is achieved at the age of 11 and it amounts to 25.3 cm in both sexes. The difference between the maximum and minimum height is 17.6 cm, which represents a significant influence of the age factor. The influence of the age factor should not be viewed in isolation, but in interaction with the sex and body composition factors.

Common to all ages is a linear increase in countermovement jump height, with the highest increase between ages of 13 and 14 in boys - 4.4 cm, while the highest increase in jump height is between ages of 12 and 13 in girls - 3.2 cm. The combined effect of age and sex factors is reflected in the existence of linear growth in the difference in countermovement jump height at the age of 12 to 16 in favour of boys compared to girls (by age: 1.4 cm, 1.8 cm, 3.7 cm, 4.4 cm, 6.1 cm, respectively), while at the age of 11 no differences in jump height were found. Also, during linear growth in the difference of countermovement jump height, different values of the body composition factor are manifested.

In the Nikolaidis study (2014), a strong correlation (r=0.68) between age and countermovement jump height was found. In Table 2, it can be seen that the highest countermovement jump is achieved by the adult group - 41.8 cm. In addition, the lowest jump height is achieved at the age of 10, and it amounts to 19.80 cm. The difference between the maximum and minimum countermovement jump height is 22 cm, which also represents a significant influence of the age factor. Common for all ages is a linear growth in countermovement jump height, where the largest increase in the jump height of 6.1 cm is observed between the age of 12 and 14.

By comparing the differences (range) of the largest and smallest values of countermovement jump height between the study of Temfemo et al. (2009) of 17.6 cm and the study of Nikolaidis (2014) of 22 cm, a difference of 4.4 cm was obtained. The obtained difference represents a stronger influence that is a higher intensity of age factor in the Nikolaidis study (2014), where there are more age categories. Therefore, it can be concluded that the age factor in a larger age range has a greater influence on countermovement jump height

- 4.4 cm. In absolute terms, the age factor of 22 cm greatly increases countermovement jump height.

Body composition

Body composition implies a relative representation of various elements in a person's total body weight. The basic elements of the structure of the human body are body water, fat-free mass, and fat body mass. The fat-free component consists of bone tissue, muscle tissue, internal organs, and "essential" fat. The fat component is "irrelevant" fat. When jumping up, body weight together with the action of gravity (g=9.81 m/s2) represents a resistance that opposes the direction of action of an athlete's muscular force. The greater the resistance to movement, the greater the muscular force that must be exerted in order to achieve greater countermovement jump height.

The study of Temfemo et al. (2009) in Table 4 shows the results of the body composition variables of boys and girls. It can be concluded that the highest countermovement jump height of 42.9 cm is manifested at the highest values of variables: body height of 174.1 cm, body weight of 62.8 kg, body mass index of 21.5%, fat percentage of 18.5%, a fat-free component of 51.2 kg, percentage of fast-twitch muscle fibres of 31.8%, at the age of 16 in boys. On the other hand, the lowest countermovement jump height of 25.3 cm is manifested at the lowest values of variables at the age of 11 in both sexes. The difference between the maximum and minimum countermovement jump height is 17.6 cm. Common to all body composition variables is that they show a linear increase as the age increases in boys and girls.

Analysing the differences in body composition variables by age, in countermovement jump height the biggest difference is 4.4 cm, which is manifested in boys between the age of 13 and 14, where there are the following differences between the values of body composition variables: body height 6 cm, body weight 4.1 kg, body mass index of 0.4%, fat percentage 1.3%, fat-free component 2.7 kg, percentage of fast-twitch muscle fibres of 2.3%. In addition, the smallest difference in countermovement jump height of 1.3 cm is manifested in girls between the age of 15 and 16, where there are far less differences between the values of body composition variables than the maximum height of the jump: body height of 0.6 cm, body weight of 1.2 kg, BMI of 0.3%, percentage of fat of 0.6%, fat-free component of 0.5 kg, percentage of fast-twitch muscle fibres of 0.5%. Based on the above, it can be concluded that larger differences in the values of body composition variables by age condition a larger difference in countermovement jump height. Therefore, it can be concluded that the body composition factor acts in combination with the age factor (boys in that period, under the influence of the male sex hormone, differ significantly in biological age in relation to chronological age).

The Nikolaidis study (2014) in Table 5 shows the results of body composition variables of age groups of football players. It can be seen that the highest (absolute) countermovement jump height of 41.8 cm is manifested at the highest values of variables: body height of 177 cm, body weight of 74.1 kg, BMI of 23.6%, fat-free component of 62.1 kg, except for the percentage of fat of 15.9% in the adult group of football players. On the other hand, the lowest countermovement jump height of 19.80 cm is manifested at the lowest values of variables: body height of 137 cm, body weight of 33.60 kg, BMI of 17.8%, a fat-free component of 27.80 kg, the percentage of fast twitch muscle fibres of 22.1%, except the fat percentage variable of 16.4% at the age of 11 in football players. The difference between the maximum and minimum countermovement jump height is 22 cm. Common for all body composition variables is that they show a linear increase as the age increases, except for the fat percentage variable (%). Fat percentage (%) is a variable whose value can be manipulated by nutrition, which is not included in the subject of the research in this study.

Table 5. *Results of average values of fat-free body component and countermovement jump height for all age groups* (Nikolaidis, 2014)

Variables	**Age categories**					
	10 (n=17)	**12 (n=27)**	**14 (n=70)**	**16 (n=92)**	**18 (n=33)**	**Adult group (n=36)**
Body height (cm)	137	146	160	171	175	177
Body weight (kg)	33.6	42.50	50.8	62.6	66.6	74.1
BMI (kg/m2)	17.8	19.60	19.70	21.2	21.9	23.6
Fat percentage (%)	16.4	19.3	16.1	15.4	14.4	15.9
Fat-free component (kg)	27.8	33.9	42.4	52.8	56.9	62.1
Countermovement jump height (cm)	19.8	22.8	30.0	36.1	40.8	41.8

Analysing the differences in the body composition variables by age groups in countermovement jump height, the biggest difference is 7.2 cm, which is manifested between the groups aged 12 and 14, which show the following differences between the values of body composition variables: body height 14 cm, body weight 8.3 kg, BMI of 0.10%, fat percentage 3.2%, fat-free component 8.5kg. The smallest difference in countermovement jump height of 1 cm is manifested between the age groups of 18 years and adults, where there are far smaller differences between the values of body composition variables than the maximum jump height: body height of 2 cm, body weight of 7.5 kg, BMI of 1.7%, fat percentage of 1.5%, fat-free component of 5.2 kg. Based on the above, it can be concluded that in summary (collectively), larger differences in the values of body composition variables condition a larger difference in countermovement jump height. Therefore, as in the study of Temfemo et al. (2009), it can be concluded that the body composition factor acts in combination with the age factor, where boys differ significantly in biological age in relation to their chronological age.

Based on the analysis and comparison, it can be concluded that the body composition factor acts in combination with the age factor (wider range/range of age categories) and the sex factor (boys achieve higher jump heights) in the Nikolaidis study (2014) and greatly affects countermovement jump height of 22 cm, which is 4.4 cm more than in the study by Temfemo et al. (2009). Based on the previously analysed data, in absolute terms, the combined action of the sex, age, and body composition factors greatly influence the increase in countermovement jump height.

CONCLUSION

In this paper, it was found that all the analysed factors influence countermovement jump height. The greatest influence is exerted by the performance technique factor, where the use of arm swinging greatly influences the increase in countermovement jump height. Therefore, if the goal is to test the readiness of athletes in specific conditions, such as a high jump in volleyball, basketball, high jump in athletics, and others, it is recommended to perform countermovement jump with arms swinging. However, if the leg strength is being tested, it is recommended to perform countermovement jump without arm swinging. The type of training is a factor that to a moderate extent, through the plyometric training program, influences the increase of countermovement jump height. When applying plyometric training, it is necessary to take into account the current level of preparation of athletes, as well as previous experience in performing plyometric exercises, and therefore dose the training load. The instruction factor in contingent action with the performance technique factor has a small to moderate influence on increasing countermovement jump height, and therefore a contingent and simultaneous application of these factors is recommended. The analysis of internal factors indicate that there is a contingent influence of the age, sex and body composition factors. The combined action of the mentioned factors manifests the greatest influence on countermovement jump height. The larger the range in years, the greater is the intensity of the influence of the age factor, which results in greater differences in countermovement jump height. By monitoring and managing body composition variables in accordance with the specifics of a certain age, it is possible to influence the achievement of higher countermovement jump height. With the sex factor, higher heights are achieved in boys at almost all ages, where there are also higher values of the body composition variables. The findings can be useful for the identification and selection of young athletes. Analysis and in-depth knowledge of external and internal factors influencing countermovement jump height can be useful to trainers and other professionals depending on the needs and desired goal of its application. For more precise measurement of the level of the influence of the stated and other factors, it is necessary to prepare in advance the scale of influence with defined criteria and values for distribution by levels in the given scale.

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