

RANGE OF MOTION IN SELECTED JOINTS IN RELATION TO SPORTS PERFORMANCE AND TECHNIQUE EFFECTIVENESS IN WEIGHTLIFTING

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Abstract

Introduction. The aim of the study was to verify or falsify the role of flexibility as the ability that distinguishes weightlifting champions from their rivals in lower sports classes. The aim of the study was also to assess the relationship between the results in snatch and clean and jerk, technique effectiveness, mobility in the shoulder joint, dorsal extension of the foot and forward bending of the spine. **Material and methods.** The study included 24 men training weightlifting – members of the Polish national team ($n = 10$) and members of one of Warsaw sports clubs ($n = 14$). Measurements were performed of active ranges of movement of the shoulder, flexion and extension in the shoulder joint, forward bending of the spine and dorsal extension of the foot in the ankle joint. The technique efficiency coefficients were calculated and the sports results were converted into Sinclair points. **Results.** Significant differences ($p \leq 0.05$) were noted in dorsiflexion of the foot in the ankle joint and forward bending of the spine in the tested groups. National team members were characterised by higher mobility than sports club members. There were no significant differences in flexion and extension movements at the shoulder joint between the groups. **Conclusions.** Significant correlations were found between the range of forward bending of the spine ($p \leq 0.001$) and the range of dorsiflexion movements of the right ($p \leq 0.001$) and left ($p \leq 0.01$) foot, and sports performance in the snatch and clean and jerk, as well as in technique effectiveness. Achieving high sports performance in weightlifting may be limited by a low joint range of motion.

Key words: weightlifting, snatch, clean and jerk, flexibility, sports performance, technique effectiveness

Introduction

The snatch and clean and jerk are strength and speed exercises that require the maximum involvement of many muscle groups and an adequate range of motion in many joints [1]. During the performance of lifts, weightlifters achieve higher instantaneous power values than athletes in other sports [1, 2]. The relationship between measurable values of various predispositions (traits) of motor skills and the results achieved in strength and speed disciplines (including weightlifting) has long been the subject of research. Platonov showed a positive correlation between increasing the height of the centre of gravity elevation in the CMJ (Counter Movement Jump) and improved performance in the snatch and clean and jerk [3]. A significant correlation between the ability to perform speed exercises and the effectiveness of snatch and clean and jerk techniques was observed by Oleshko [4] and Lisakovsky et al. [5]. As selection criteria for weightlifting, exercises that provide opportunities to measure the value of developed power and at the same time show significant correlations with improved performance of lifts (high jump, standing long jump, 30-metre run, jump – CMJ and from a half squat) are recommended [3, 4, 5, 6, 7].

Thus, the existing results of the research indicate a relationship between sports results in weightlifting and speed abilities as well as coordination – understood as the structure of movement similar to vertical jump and lower limb power. In contrast, few publications show a relationship between sports performance and flexibility. There are only discrete suggestions

concerning the importance of this component of motor skills. Stone et al. point to the important influence of movement speed and flexibility [8], and Fry et al. consider that for successful weightlifting, flexibility is one of the necessary components [9]. In turn, Ernst and Jensen describe the snatch and clean and jerk as movements involving the whole body that combine strength, power, speed, movement awareness, technique and flexibility [10].

Polish sports theorists define flexibility as the ability to perform high amplitude exercises in accordance with the physiological mobility of the joints involved in a given movement [11, 12]. Moreover, sports practitioners, depending on the nature of the activity performed in sports training, usually distinguish three types of flexibility: dynamic, active and passive. Active flexibility is most closely related to the level of sports performance [13]. This type of flexibility is the most difficult to develop because of the muscle strength required to maintain the desired position [14]. Kurz adds special flexibility, which is characteristic of each sport, and the effectiveness of the technique of performing a special movement task may depend on its level [15]. Both classic lifts require performing a full squat with a barbell conditioned by the level of flexibility [9]. An activity that checks special flexibility in weightlifting is the snatch squat, which reflects the position of accepting the barbell in the snatch, after the resistance descent phase [16]. It is a very specific movement, used in weightlifting training as an auxiliary exercise, and its analysis, due to angular settings in the joints, can be used to detect abnormalities related to mobility restrictions and thus pre-

vent injuries [17]. Another activity which checks general flexibility in weightlifting is the forward bend of the torso with straight legs – standing on a platform, which, besides the snatch squat, is an element of fitness tests summarising the comprehensive training of young weightlifters [18, 19]. The snatch and clean and jerk are exercises that require high amplitude movements at many joints and it can be assumed that an optimum level of flexibility can improve their effectiveness and therefore promote better utilisation of the athletes' strength potential. These reasons seem to be sufficient to undertake research on flexibility in the context of its importance for achieving high levels of performance in weightlifting.

Study aim

The aim of the study is to evaluate the relationship between the performance in the snatch and clean and jerk, technique effectiveness, mobility in the shoulder joint, dorsiflexion of the foot and forward bending of the spine.

Material and methods

The study included 24 men practising weightlifting – 10 members of the national team (Cadre I) (international master class) and 14 members of one of Warsaw sports clubs (Club II) (national master class, class I) (Tab. 1). The athletes from Club II group were on average significantly older and taller than the athletes from Cadre I group. However, mean differences in body weight were not significant ($p < 0.05$).

Active ranges of motion of flexion and extension of the arm at the shoulder joint, forward bending of the spine, and dorsiflexion of the foot at the ankle joint were measured. Mobility in the shoulder, ankle and knee joints was measured with a two-arm goniometer from MSD with an accuracy of 1° , while the mobility of the spine was measured using a specialised measuring tape with an accuracy of 0.5 cm. All measurements were performed according to the methodology described by Zembaty used in physiotherapy and sports medicine [20].

Sports results achieved by athletes of different weight categories, in order to compare their actual value, were calculated as the product of the Sinclair coefficient for body weight of each athlete and the sum of kilograms in Olympic weightlifting. The Sinclair coefficient is determined by statistical methods to the nearest 100 g of body weight at the end of the Olympic year and is valid for the following 4 years [21].

Technique effectiveness was defined in [%] as the quotient of the records in classic lifts (separately for the snatch and clean and jerk) and squats with a barbell on the shoulders, as per the formula presented by Li, according to which a higher

Table 1. Characteristics of participating athletes (\pm SD) and group homogeneity coefficients (%).

		Cadre I	Club II
Age [years]	Average \pm SD	*19.1 \pm 2.1	*32.4 \pm 5.3
	CV	11%	16%
Body weight [kg]	Average \pm SD	90.0 \pm 22.2	88.7 \pm 11.1
	CV	25%	13%
Body height [cm]	Average \pm SD	*177.1 \pm 6.7	*182.4 \pm 6.3
	CV	4%	3%

* – $p \leq 0.05$; CV – coefficient of variation indicating homogeneity of a trait across groups.

quotient percentage score means higher technique effectiveness [22].

Test procedure

The athletes performed the tests immediately after their morning training unit, before their meal, between 12:30 and 14:00. Mobility measurements in the selected joints were performed twice for each joint. The arithmetic mean of the trials was used for comparisons and calculations.

Statistical procedures

Student's t-test for independent samples ($p \leq 0.05$) was used to compare the study groups for differences in joint mobility. The coefficient of variation (CV) was calculated to determine the degree of variation in the trait across groups as a percentage. A higher score indicates heterogeneity (diversity) of the trait in the group, while lower score values indicate homogeneity of the trait. Relationships between the ranges of motion in selected joints and technique effectiveness and sports performance were sought using Pearson's linear correlation. Pearson's linear correlation coefficient values above 0.404 were considered significant.

Results

The ranges of mobility in the shoulder, spine, and ankle joints were compared between the study groups. Average scores, trait homogeneity indices and the level of significance of differences between the athletes from Cadre I and Club II are presented in table 2.

The athletes from Cadre I were characterised by significantly greater mobility in the ankle joints and the spine than the athletes from Club II. Due to low ranges of motions in these joints, even relatively small absolute values of changes in the ranges of motion (3° - 5°) indicated that the changes were significant. However, it should be noted that the spread of the homogeneity coefficient of the range of motion in these joints was large (9-12%).

Table 2. Mean ranges of motion and values of homogeneity coefficient in individual joints (\pm SD)

			Cadre I	Club II
Arm flexion [$^\circ$]	Right	Average \pm SD	184.6 \pm 15.6	180.4 \pm 10.5
		CV	8%	6%
	Left	Average \pm SD	184.8 \pm 15.1	179.6 \pm 9.3
		CV	8%	5%
Arm extension [$^\circ$]	Right	Average \pm SD	54.9 \pm 10.0	48.4 \pm 7.8
		CV	18%	16%
	Left	Average \pm SD	56.4 \pm 9.1	49.8 \pm 7.5
		CV	16%	16%
Dorsiflexion of the foot [$^\circ$]	Right	Average \pm SD	*20.5 \pm 5.7	*14.9 \pm 5.8
		CV	28%	39%
	Left	Average \pm SD	*20.3 \pm 5.8	*15.3 \pm 5.7
		CV	29%	38%
Spinal flexion [cm]	Average \pm SD	*14.5 \pm 2.5	*11.7 \pm 3.4	
	CV	17%	29%	

* – $p \leq 0.05$; CV – coefficient of variation indicating homogeneity of a trait across groups.

Table 3. Values of correlation coefficients concerning the relationship between joint mobility, sports performance (Sinclair points) and efficiency coefficient of the snatch and clean and jerk technique.

	Arm flexion		Arm extension		Dorsiflexion of the foot		Spinal flexion
	Right	Left	Right	Left	Right	Left	
Sports performance	0.06	0.10	0.35	0.33	0.58**	0.50*	0.52**
Snatch	0.17	0.10	0.35	0.18	0.676***	0.639***	0.719***
Jerk	0.13	0.09	0.35	0.17	0.621***	0.56**	0.736***

* – $p \leq 0.05$; ** – $p \leq 0.01$; *** – $p \leq 0.001$.

The ranges of motion of flexion and extension at the shoulder joint were not significantly different between groups. Although mean differences in absolute ranges of motion were greater (4° - 7°) than in the case of the spinal and ankle joints, the scale of possible ranges of motion at these joints (180°) resulted in insignificant differences. It is also confirmed by non-significant changes in the homogeneity coefficient (largest spread of 3%).

The correlation between mobility in the shoulder joints, the spine, ankle joints and technique effectiveness and sports performance is shown in table 3.

There were significant correlations between the effectiveness of the snatch and clean and jerk techniques and the range of motion of dorsiflexion of the right and left foot and forward bending of the spine. Significant values of Pearson's linear correlation coefficients were in the upper limits of the range (0.5; 0.7), and for spine mobility above 0.7.

There were significant correlations between sports results converted into Sinclair points and the range of motion of dorsiflexion of the right and left foot and forward bending of the spine. The obtained values of Pearson's linear correlation coefficient were in the lower limits of the range (0.5; 0.7). The most significant difference between the study groups occurred in forward bending of the spine.

Discussion

The available literature most often discusses flexibility in terms of the effects of applied stretching of muscles and other elements of the musculoskeletal apparatus in order to improve the effectiveness of their work [23, 24, 25, 26]. A large body of literature is also devoted to the study of exercises of different nature, the use of which can improve flexibility, and thereby impact various desired parameters of the muscular system [27, 28, 29]. In relation to weightlifting, the aforementioned directions of the discussion appear relatively rarely, although this does not mean that there is a lack of valuable positions in the scientific dispute in the field of problems searching for relations between flexibility and sports results, movement technique and possibilities of correct (optimal) muscle activation [30, 31, 32, 33]. In terms of issues related to mobility in individual joints, the conclusions of the study by Macrum et al. seem useful, indicating that limiting the range of dorsiflexion of the foot when performing a squat with a barbell on the shoulders, results in reduced activity of the quadriceps femoris muscles and increases knee valgus during the exercise [34]. Our study showed significantly greater mobility in the ankle joints in higher-level athletes than in lower-level athletes. In the light of these results, it can be concluded that athletes of the highest sports class, thanks to increased flexibility of this part of the musculoskeletal apparatus, can avoid adverse phenomena that prevent them

from performing the squat correctly and without provoking injuries, which is after all one of the phases of the snatch and the clean and jerk [35, 36, 37]. Such correlations also seem to be confirmed by the work of Adelsberger and Tröster, which indicates that athletes with better lower body mobility (ankle and hip joints) maintain a more upright position while performing the snatch squat. Adopting an upright position results in reduced pressure on the shoulder joints which improves the ability of this weak link in the movement chain and allows greater weight to be lifted [38]. Although our study did not show a significant relationship between the groups in shoulder joint mobility ranges, sports performance and technique effectiveness, such relationships are indicated by some publications. According to Li et al., reduced mobility in the shoulder joints due to an injury is one of the most common reasons for reduced performance in the snatch and clean and jerk of high-level weightlifters [39]. Fry et al. showed a connection between high athletic performance and a smaller amplitude of flexion movement at the shoulder joints and a smaller range of trunk tilt relative to the ground in the snatch squat [9].

In terms of improving sports performance and technique effectiveness, significant relationships with intervertebral and hip joint mobility are more often indicated. Chiu et al. showed that weightlifters performing better in the snatch (compared to rivals in the same weight category) adopt a deeper position during the barbell acceptance phase [40]. Ernst and Jensen, after seven weeks of using the yoga system with weightlifters with average athletic performance (mean Sinclair score 259.85 ± 64.13), reported a significant increase in mobility in the intervertebral joints as well as the hip and ankle joints in the snatch squat position [10]. Our study indicated a significantly greater range of motion in the forward trunk bend in higher-class athletes compared to lower-class athletes, and the mean range of this movement was significantly greater than that defined as the population norm [41, 42, 43]. This points to the need for top weightlifters to maintain an increased level of flexibility (despite increased tonus and muscle mass) in order to maintain a high rate of technique performance to improve athletic performance.

Conclusions

High correlation coefficients between the mobility of the ankle joints and spine, and sports performance and technique effectiveness indicate that weightlifters need to maintain a high level of flexibility in order to optimally use their strength potential.

Insignificant correlations between sports performance, technique effectiveness and the range of motion in the shoulder joints of weightlifters at different levels of competition may indicate an overestimation of the importance of flexibility training of these joints in improving performance.

Due to significantly greater ranges of motion of weightlifters of higher sports classes in the ankle and knee joints and the spine, the opinions that flexibility decreases with increasing sports class of weightlifters should be falsified.

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