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INTERDISCIPLINARY TOPICS

BIOMECHANICAL JUMP CHARACTERISTICS OF ADOLESCENT BASKETBALL FEMALE PLAYERS AFTER AN ISOMETRIC STRETCHING PROGRAM

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Abstract: The effects of isometric stretching on the muscle-tendon-joint biomechanics in the literature data are contradictory. The aim of the study was to verify the effectiveness of the applied isometric stretching program for the improvement of jump performance of six adolescent basketball female players (17–19 years). The isometric stretching protocol with eleven exercises was used after the last daily regular training program, four times per week for 40 minutes. All exercises were repeated three times with detention duration 15 seconds for 11 weeks. Chronojump DIN-A1 contact platform (Spain), detecting a single jump with one phase of flight, was used to evaluate eight important biomechanical jump characteristics for the participants. The obtained Mann-Witney statistics of the measured parameters for our six participants shows contradictory results and individual stretching body adaptation. The obtained statistical significant decrease only for DJ Power (drop jump power) does not allow to make the important conclusions for the applied isometric stretching program effectiveness. The presented results underline that lower extremity control and performance are strongly related with the motion and synergy work of the upper limbs. In addition, the presented data draw attention to improving coordination between the lower and upper body movements, emphasizing the individual characteristics of each athlete for target increasing of lower limbs biomechanical performance.

Key words: isometric stretching, jump height, lower extremity elasticity index, usefulness of arms index.

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1 Introduction

Elucidating the complex processes that determine the ability of the human body to adapt to specific intense training programs is critical to improving athletic performance in all sportsmen. Physical exercise has enormous potential in combating the global "epidemic" of chronic metabolic and inflammatory diseases, such as obesity, metabolic syndrome, type 2 diabetes mellitus, and others [1]. Physiological reactions of the body under the influence of physical exercise are complex, insufficiently studied and analyzed, in view of the wide spectrum of hemorheological, metabolic, immunological and hormonal changes [1–3]. It is known that the immediate systemic physiological response to intense exercise is highly dependent on the type, duration, intensity, cyclicity and duration of physical activity. The individual level of training (training status) of athletes also affects the body's adaptive response to long-term changes in relationships to repeated physical exertion [1].

The main factors determining achievements in sports are directly related to the biomechanical properties of blood and its rheological behavior [1].

Extensive contemporary research has been published analyzing specific bodily answers in response to various training regimens and their relationship to the age, sex, training level and health status of athletes [4–7].

Vertical jump performance has been well studied in the past [8, 9]. An important aspect of vertical jump performance is the contribution of upper limb segments to force production during jump take off [10, 11].

According to Rodano et al., 1996, the vertical jump can be defined as a complex series of ballistic multijoint actions where the muscles around the ankle, knee, and hip joint collectively operate to produce patterns of movement [12]. The correlation of lower extremity technique with upper extremity performance of adolescent basketball players is essential for the overall sporting achievement.

From biomechanical point of view, stretching has been characterized by Weerapong et. al., (2004) as "a movement applied by an external and/or internal force – in order to increase muscle flexibility and to improve the joint range of motion (ROM)" [13]. The aim of stretching exercises is to increase muscle-tendon unit length and to improve joint flexibility, as well as to decrease the risk of soft tissue injuries [14–19].

Various stretch techniques have been examined and compared in the world scientific literature. Unfortunately, current results of the chronic effects of static stretching (SS) exercises on the muscle strength, flexibility, joint ROM, intra-articular movements and muscle power are controversy [17, 20–23].

The main question related to the stretching biomechanics is if regular stretching programs change the joint-ligament-tendon-muscle unit mechanical properties?

Stretching effects were reported, but a large heterogeneity was seen for most of the variables obtained [4].

The purpose of the present study was to verify the effectiveness of the applied isometric stretching program (11 stretching exercises) for the improvement of jump performance of adolescent (17-19 years) basketball female players.

2 Materials and Methods

Six basketball female players from the "Rilski Sportist" club from Samokov town, Bulgaria, aged from 17 to 19 years, were included in the study.

The isometric stretching protocol with eleven exercises was used after the last daily regular training program, four times per week, for 40 minutes (Fig. 1). All exercises were repeated three times with detention duration 15 seconds for 11 weeks (from 30.01.23 till 12.04.23). The isometric stretching protocol is shown in Fig. 1. It includes 5 isometric stretching exercises in standing, and six exercises in sitting body position.

Chronojump DIN-A1 contact platform (Spain), detecting a single jump with one

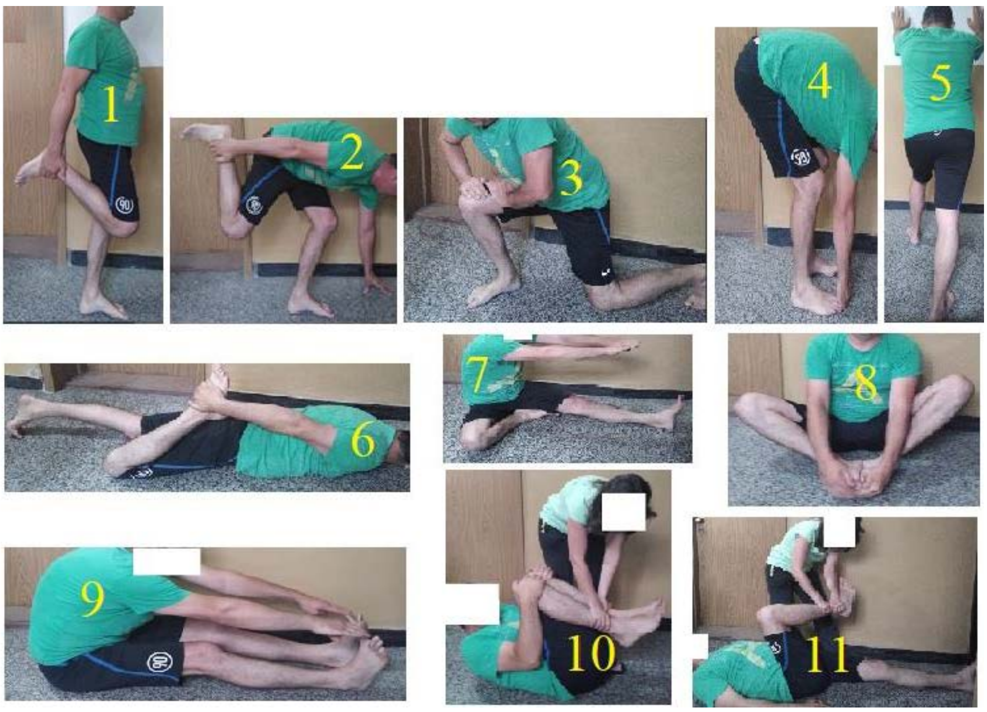


Fig. 1. Isometric stretching protocol.

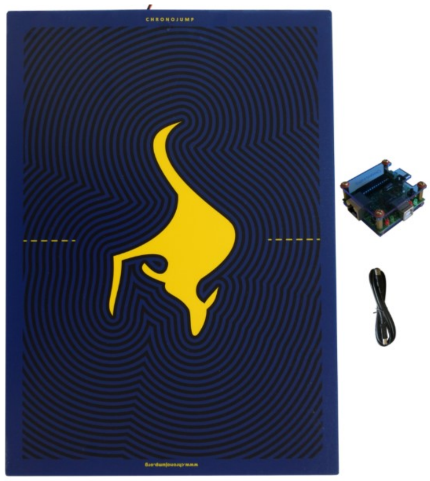


Fig. 2. Chronojump DIN-A1 contact platform (Spain).

phase of flight, was used to evaluate eight important biomechanical jump characteristics (Fig. 2).

The measured quantitative biomechanical characteristics of different single jumps in three repetitions, with the best result selected, are as follows:

- Squat jump height (SJ) in centimeters;
- Counter movement jump height (CMJ) in centimeters;
- Abalakov jump height (ABK) in centimeters;
- Drop jump height (DJa) in centimeters with arms using (initial height 10 centimeters);
- Elasticity index IE (relative units) – elasticity index represent force increment due to the elastic energy acumulated during the shortening-stretching cycle. Elasticity index formula between SJ and CMJ jumps heights [24] is defined as

$$\mathrm{IE} = \frac{(\mathrm{CMJ} - \mathrm{SJ})}{\mathrm{SJ}} * 100\,; \quad (1)$$

- Index of drop and arm reaction – IRa (relative units) [24]

$$\mathrm{IRa} = \frac{(\mathrm{DJa} - \mathrm{CMJ})}{\mathrm{CMJ}} * 100\,; \quad (2)$$

- Arms use index (AUI, relative units) represent force increment due to the arms using [24]

$$\text{AUI} = \frac{(\text{ABK} - \text{CMJ})}{\text{CMJ}} * 100\,; \tag{3}$$

- Drop jump power – DJ Power [24]

$$\text{DJPower} = \frac{\text{mass} * g * (\text{fall height} + (g/8) * (t_f^2))}{t_f + t_c}\,, \tag{4}$$

where t_f is flight time, and t_c is contact time at DJa jump, g is gravity on earth, fall height is initial height from which the athlete fall to the chronojump platform.

3 Results

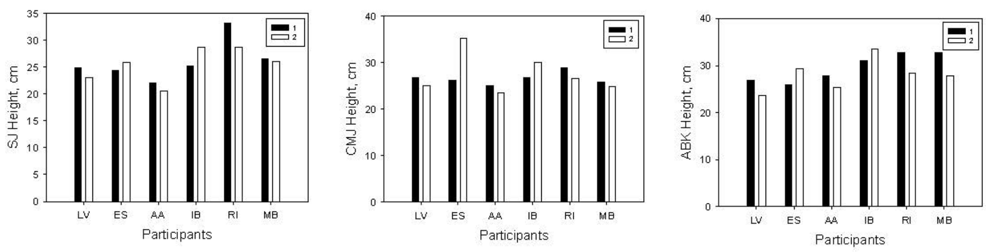
The results obtained on changes of the parameters used in the study are shown in Figs. 3–5 and in Table 1 and 2.

4 Discussion

In the SJ, CMJ and ABK jumps, we obtained identical trends: in four of the participants there is always a decrease in the height of the jump, and in the remaining two – an increase (Fig. 3, Table 2).The DJa height was increased after isometric stretching program for four participants and was decreased for the two (Fig. 4a, Table 2).

The Elasticity index IE was increased for three participants and was decreased for the others three (Fig. 4b, Table 2).

Arms use index (AUI) was not statistical significantly changed, but for five participants this parameter shows decreased levels (Fig. 5).



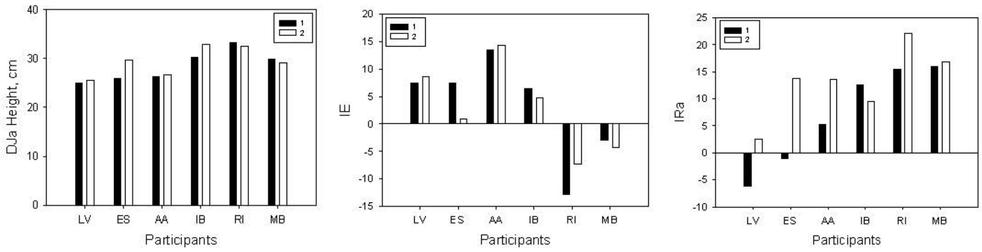
(a) (b) (c)

Fig. 3.)a) Squat jump height (SJ) before (1) and after (2) stretching protocol; (b) Counter movement jump height (CMJ) before (1) and after (2) stretching protocol; (c) Abalakov jump height (ABK) before (1) and after (2) stretching protocol.

Table 1. Biomechanical characteristics before (1) and after (2) stretching protocol

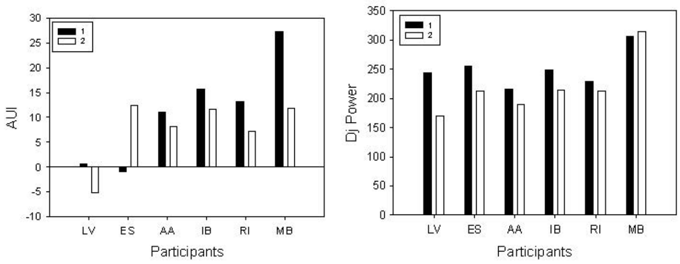
	SJ Height, cm	CMJ Height, cm	ABK Height, cm	DJa Height, cm	IE	AUI	IRa	Dj power
30.01.23 (1)								
Mean	26.03	26.57	29.52	28.45	3.17	11.16	6.98	249.71
Std. dev.	±3.78	±1.31	±3.06	±3.21	±9.46	±10.44	±9.18	±31.24
12.04.23 (2)								
Mean	25.45	27.52	28.04	29.37	2.83	7.70	13.02	**218.88**
Std. dev.	±3.19	±4.39	±3.40	±1.20	±8.05	±6.67	±6.65	**±50.35***
								p-value is 0.04182

*$p \leq 0.05$



(a) (b) (c)

Fig. 4. (a) Drop jump height (DJa) before (1) and after (2) stretching protocol; (b) Elasticity index (IE) in relative units before (1) and after (2) stretching protocol; (c) Index of drop and arm reaction – IRa (relative units) before (1) and after (2) stretching protocol.



(a) (b)

Fig. 5. (a) Arms use index (AUI) in relative units before (1) and after (2) stretching protocol; (b) Drop jump power index in Watts before (1) and after (2) stretching protocol.

Table 2. Individual isometric stretching influence with direction on study participants

Participants' indices	LV	ES	AA	IB	RI	MB
Squat jump height	–	+	–	+	–	–
Counter movement jump height	–	+	–	+	–	–
Abalakov jump height	–	+	–	+	–	–
Drop jump height with arms using, DJa	+	+	+	+	–	–
Elastisity index, IE	+	–	+	–	+	–
Index of drop and arm reaction, IRa	+	+	+	–	+	+
Arms use index, AUI	–	+	–	–	–	–
Drop jump power, DJ power	–	–	–	–	–	+

The index of drop arm reaction (IRa) in relative units shows lack of statistical significant difference after isometric stretching program. For five participants we obtained that IRa is elevated.

Only for DJPower index was obtained Mann-Whitney statistical significant decrease after eleven weeks with stretching program (Table 1).

5 Conclusions

The obtained Mann-Whitney statistics of the measured parameters for six participants in the isometric stretching program, shows contradictory results and individual specific stretching body adaptation. The obtained statistical significant decrease only for DJ Power does not allow to make the important conclussions for the effectivness of applied isometric stretching program. Furthermore, the small tested group - in combination with the lack of an efective individual control for stretching program application for all tested participants, leads to conclusion that a more comprehensive analysis, using similar biomechanical methods, is needed for improvement on the effectivness of the stretching program used.

The results presented unerline that lower extremity control and performance are strongly related with the motion and synergy work of the upper limbs. In addition, the presented data draw attention to improving coordination between the lower and upper body movements, emphasizing the individual characteristics of each athlete.

The lack of statistically significant difference for the elasticity index (IE) allows us to suggest an increase or decrease (in relation with individual biomechanical profile) of the duration, frequency and number of stretching exercises in the athletes training program in the future experimental approach. This would increase the lower limbs elasticity index and improve force increment due to the elastic energy acumulated during the shortening-stretching cycle.

In addition, from the presented relations it is clear that the excellent sports achievement is a result from the complete set of all factors that determine it. However, a more comprehensive analysis, using different biomechanical methods and bigger participant groups, is needed for the in depth conclusions.

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