MAINTANING BODY BALANCE IN EXTREME POSITIONS

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Abstract. The aim of the paper is the analysis of the process of maintaining body balance during handstand and one leg toe stance, which are the basic exercises in artistic and rhythmic gymnastics – respectively. The subject of the study were ten artistic gymnasts (5 boys, 5 girls) who were asked to stand on hands and five girls – rhythmic gymnasts, who stood on tiptoe of one leg. Both tasks were repeated three times. Participants stood on KISTLER force platform for 10 and 20 s – respectively. The displacement of the foot and hands center of pressure (COP) in time function were recorded. Factors: standard deviation, range and frequency of COP displacement on sagittal and frontal planes were calculated in this study. The maintaining of body balance during the handstand, executes mainly in an anterior – posterior direction which differs from one leg toe stance where the frontal displacement of COP is more important for body stability.

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Key words: Body balance - Force platform – Gymnasts - Handstand - One leg tiptoe stance

Introduction

Gymnastics is characterized by the motorial coordination of highest standards. Maintaining the body balance during various exercises i.e. handstand (basic in acrobatics and artistic gymnastics) or one leg tiptoe stance (standard in rhythmic gymnastics) is the element of the high level of the motorial coordination achieved through the training.

Maintaining of balance during the inverted stance was the issue examined by couple of authors [10,12]. Athlete, while standing on hands, aims in minimization of body segments motion for the body mass centre stability and keeping its vertical throw within the support area [1,4,9]. The balance regulation during the handstand is obtained alike in the foot stand i.e. through displacement of the centre of

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pressure (COP) towards fingers or wrist joint in the sagittal plane or right or left side in the frontal plane. Maintaining the balance in the inverted stance on hands demands the maximal straightening of the wrist joint as well as serious motion restraint. The regulation of balance in this unnatural position goes mainly through the enlargement of the pressure of fingers on the ground as a response to the movement of the centre of gravity (COG) towards fingers or of the wrist joint pressure when COG moves towards it [10]. The time series of the oscillation of the hands center of pressure may be the starting point for the comparison of processes of the balance regulation in extreme balance positions presenting the basic ability in gymnastics.

The difficulty of keeping the equilibrium during one leg toe stance flows from the minimal area of foot support - it is an area shaped as a rectangle dimensioned by the fore-foot size. Additional hindrance becomes the second leg lifted up to the head level and supported by an arm i.e. side balance (one of basic exercises in rhythmic gymnastics).

Discussed in this thesis exercises differ with each other with the body orientation (the reverse from natural position in the handstand) and the supporting area - both palms surface and area between them in the handstand and the fore-foot scope in the one leg toe stance. However, both positions seem to be equally extreme as considering the equilibrium maintenance in a certain time. From the biochemical perspective the difficulty is keeping COP between the stability borders [1,7].

The aim of this work is the analysis of balance maintaining process during the performance of chosen basic exercises in gymnastics. There can be assumed that the motory and responsible for it nervous system function in the same manner despite the body orientation or the prop area size. Nevertheless, the task in both is the same namely: keeping the equilibrium for specified time.

This research accepted thesis that the balance mechanism is similar in the handstand and side balance despite of extremely different physical conditions of chosen body positions.

Materials and Methods

The subject of the study were 10 athletes (5 girls and 5 boys) of the artistic gymnastics at the level of III, II, I class from Gymnastic Society in Nysa aged 12-15 years old. Their abilities were proper for the performance of the handstand from one leg take off and keeping this position for 10 s. The second task - side balance stance with one leg lifted up to head level was performed by 7 athletes of II, I and master class in rhythmic gymnastics (aged 12-17) and lasted for 20 s. Participants stood on the KISTLER force platform joined with the computer. Each trial was repeated thrice. The displacement of COP was recorded in two planes: sagittal (anterior-posterior) and frontal (medial-lateral). The sampling rate was 25 Hz (Figs. 1 and 2).

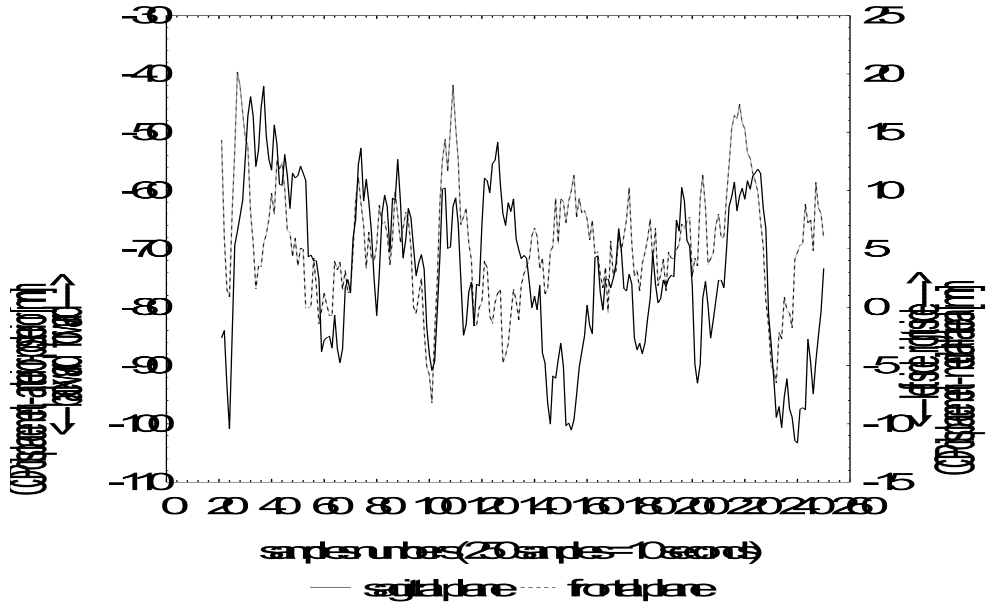

Fig. 1
Exemplary time series of COP displacement on both palnes during the hands stance

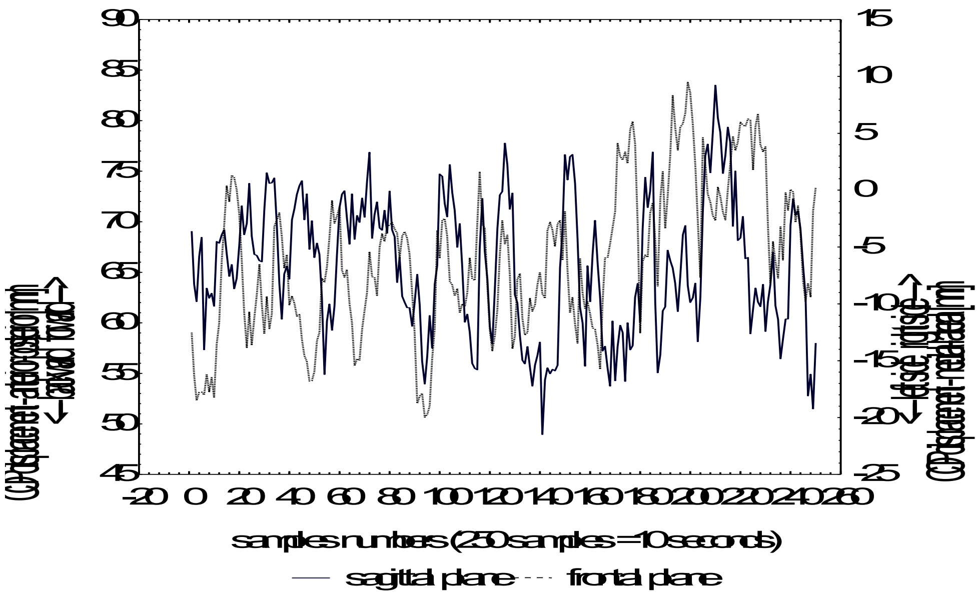

Fig. 2
Exemplary time series of COP displacement during the side balance stance

Displacements of COP were recorded during the approximately most stable position of the handstand. Not all trials were successful. As a consequence results of 30 and 19 trials of the first and second task - respectively were taken into consideration in further measurements.

Following indices were used for the comparison of the balance maintaining in two examined exercises:

1. Standard deviation (SD) - as the results scattering agent.
2. COP displacement amplitude (Ra) in the sagittal and frontal plane.
3. COP displacement frequency (F).

The first two factors are widely used in the diagram-stability measurements [3,4,7,11] and have a quantitative character.

The third mentioned agent reflects the balance quality and was calculated basing on the analysis of COP displacement [5]. The actual signal in both exercises had a two or more peak spectrum (Fig. 3) therefore, the F values were equal to a weighted mean of respective peak frequencies. The above values were presented in Table 1. Calculations were performed with the STATISTICA 5.0 programme.

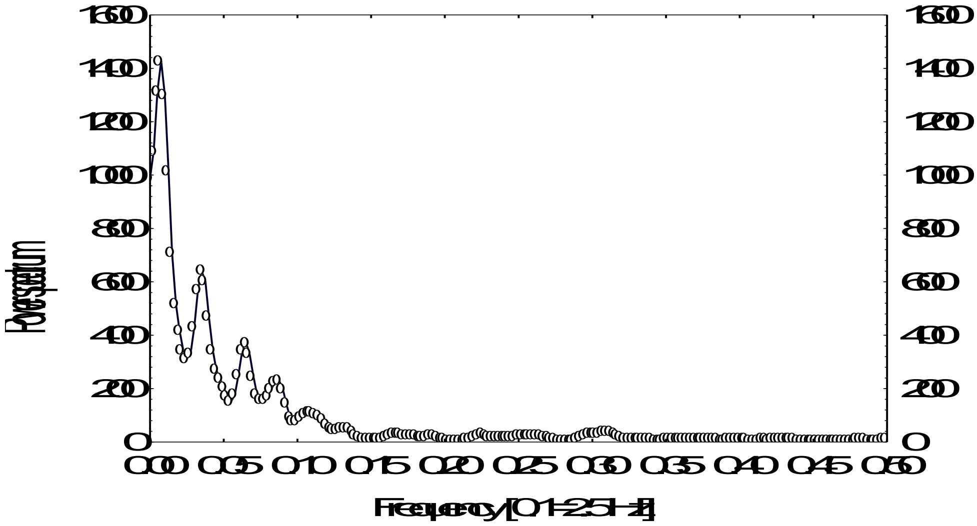

Fig. 3
Exemplary plot of power spectrum of COP shift in the sagittal plane in the side balance stance

Results

The averages and standard deviations were calculated. The test of differences significance between indices in both exercises as well as the COP planes oscillation were made for each athlete. Results are presented in Table 1.

Table 1
Average values of calculated indices in both tasks. Standard deviations are given in brackets

	Handstand (n=30)			Side balance stance (n=19)		
Values	SD [mm]	Ra [mm]	F [Hz]	SD [mm]	Ra [mm]	F [Hz]
Sagittal plane	14.26* (2.98)	61.55* (16.39)	0.89* (0.33)	7.17* (0.94)	38.48* (19.83)	0.56* (0.25)
Frontal plane	7.01* (2.78)	37.02* (15.75)	0.62* (0.21)	7.02 (1.91)	33.9 (5.73)	0.72 (0.33)

*significant difference at the level of p<0.001

All calculated factors i.e. standard deviation (SD), COP oscillation amplitude (Ra) and COP displacement frequency (F) in the sagittal plane show statistically significant differences between each other in both balance exercises (Table 1). It states that the motorial exercise realisation (as considering the displacement of the pressure point through foot or hands on the ground in an anterior-posterior direction) runs completely different in both exercises. These values are crucially higher in the case of the handstand.

Somewhat different results were obtained in the case of the frontal plane. Lateral displacements of COP in both exercises revealed large similarities of examined factors. Both, the COP oscillation amplitude and COP displacement frequency reached alike values during the handstand and side balance position.

Discussion

Arms and palms are not naturally destined for the body support function. As a consequence, the athlete performing the handstand must confront all the destabilizing agents - respective body parts motions - while keeping the vertical position of the centre of gravity between hands. Values of SD, Ra and F present much more higher amounts during the handstand in comparison to the one leg toe position. It is coherent with other authors' results [10] and characteristic for the hindered conditions of balance maintenance [7,12].

One foot toe stance is far more easier to perform. The mechanism of the balance maintenance is crucially different in both balance positions especially as considering the COP anterior-posterior displacements. The comparison of indices responsible for equilibrium regulation in lateral displacements of the pressure point on the ground indicated the lack of difference in this mechanism during the handstand and one leg tiptoe position. It can be assumed that the balance in both exercises is accomplished in similar manner (if we consider the lateral displacements of the pressure point on the ground only).

Such elements as size and shape of the supporting area as well as higher activity of the main body joints in the anterior-posterior direction and not aside may probably have the crucial meaning in the balance regulation mechanism. Athlete during the handstand tries to keep a stable position of the body especially in the anterior-posterior plane since most of joints present a large activity in this disposition. Somewhat easier is the case of the frontal plane where the respective body parts motions are restricted [8,9,10] and subjects display smaller scattering of results during the handstand in comparison to the sagittal plane. Additionally, the palms support area is bigger (hands spacing in breadth of shoulders) in the frontal plane than in the anterior-posterior plane (palms length) what may be the cause of the significantly smaller SD value in lateral COP displacements.

The COP displacements range in the sagittal plane is crucially higher than in the frontal plane during the handstand despite of the larger dimension of the supporting area in the medial-lateral direction. Similar outcomes were obtained by Slobonov and Newell [10].

The average frequency of COP oscillation during the handstand was higher in the anterior-posterior direction than in lateral one. According to Kuczyński [5] the COP displacement frequency grows along with the motion task difficulty. Basing on the F values in both COP planes in the handstand there can be stated that more difficult is keeping the stability in converted position and restricting body motions forward and backward than left and right sides.

Values of the scattering and amplitude of the COP displacements in the sagittal and frontal plane did not vary significantly during the one leg toe stance. It shows that gymnasts try to maintain their balance through the shift of COP forward, backward, right and left equally. The very small supporting area and large activity of the supporting leg hip joint (one hip joint is eliminated from the balance regulation in this task by the lifting up one leg) may become elements conditioning the COP point displacement in both planes alike. Similar results are presented by Golema and Stachowska [3].

The difference of COP shifts in the sagittal and frontal planes fulfils the significance condition considering the COP oscillation frequency. This factor value is higher in the frontal plane what confirms an assumption that the hip joint release being a regulator of side balance in the one leg toe stance changes the mechanism of the equilibrium regulation in comparison to situation where two supporting points occur. The above results are coherent with outcomes obtained by the group of female gymnasts and control group performing various one leg balance positions [3,11,12]. Values of COP displacement during the handstand or two leg position are usually significantly higher in the anterior-posterior than medial-lateral direction [7,8,10,12].

Conclusions

Maintaining the balance in the one leg toe stance demands both directions of COP displacement. Even more significant turns to be the frontal plane shift. It is probably the effect of the supporting leg hip joint activity which regulates the body balance. The maintaining of body balance during the handstand, executes mainly in the anterior-posterior direction what is probably elicited by a large activity of main body joints in such a body arrangement.

There cannot be stated that the body balance maintenance mechanism is similar in the hands and one leg toe stance. It seems as if the orientation of the human body and other factors connected with its equilibrium in extreme positions e.g. supporting area and/or arms strength or the activity of the key (in respective positions) body joints may have the decisive meaning in the balance maintenance during the troubled conditions of human body stability.

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