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ORIGINAL

The level of body balance in a handstand and the effectiveness of sports training in gymnastics

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background The aim of the study was to determine the level of maintaining body balance in a hand stand among gymnasts at the stage of directed and championship training and to prove a relationship with the sports result, taking into account the difficulty and the quality of exercises.

Material/Methods The study involved boys aged 11–12 years systematically training gymnastics (G1, n = 20) and 12 experienced gymnasts aged 18–26 years with an accomplished international class (G2, n = 12). Both groups comprised top athletes classified at the national and the international level. The study was conducted prior to the apparatus trial, on the day preceding competition in an official sports tournament. The trial of maintaining the body balance in a handstand was carried out in a closed room after about a 10-minute warm-up.

Results An analysis of the tests showed significant differences in the level of maintaining the body balance in a handstand. The largest one was reported in Area 95, whose field in experienced athletes was less than half the size ($\bar{x}$ =8.16cm² ±8.06cm²) of the younger group ($\bar{x}$ = 19.81cm² ±8.74cm²).

Conclusions The study of correlations of the body balance in a handstand with the level of sports preparation has shown that the level of this specific to artistic gymnastics skill plays a big role in shaping sports mastery both among young gymnasts with a few years' experience and among experienced athletes with the international class.

Key words body balance, handstand, sports result, artistic gymnastics

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INTRODUCTION

Achieving the highest level in many sport disciplines is possible, among others, thanks to athletes' proper psychophysical predispositions and a properly arranged training process. It should be noted that despite extensive research there is still a discussion on identification of talents in different sports disciplines and events. Many authors believe that, among the selection criteria for candidates for sports with a high motor complexity, particular attention should be paid to the level of movement coordination, on which the efficiency and speed of sports training largely depends [1, 2, 3, 4, 5, 6, 7]. The processes of movement coordination mainly occur owing to neurophysiological control mechanisms and the regulation of sensorimotor, perceptive, intellectual, proprioceptive and kinaesthetic functions. They depend on the functioning of the central nervous system, receiving organs – receptors and the muscular system – effectors, which are determined by genetic and environmental factors [8, 9, 10, 11, 12, 13].

In men's and women's artistic gymnastics, among the many tests and trials that define motor skills coordination, much attention is paid to the evaluation of the handstand. In many gymnastic events, this element constitutes the starting, the middle and the final position in the presented routines. The correctness of its execution requires athletes to have a high level of physical fitness and, in particular, of balance skills. Adjustment of body balance at rest as well as in a variety of motor activities is a dynamic process, which takes place through coordinated interaction of the vestibular apparatus in the inner ear, the organ of sight, deep feeling and the central nervous system. The signals received by these structures are a source of information about the body position and its orientation in relation to the external and the internal reference system [14, 15]. Keeping the upright body position in a handstand seems to be similar to the usual position on one's legs; yet this activity is extremely difficult to master. Young gymnasts acquire the ability to freely maintain static body balance in a handstand usually after about 3-4 years of sports training. This period falls between 7 and 11 years of age, when coordination motor skills are shaped the most dynamically in comparison to the remaining stages of ontogeny. An assessment of the quality of the execution of the handstand by a gymnast with a few years' training experience typically is not much different from that of an experienced athlete of the highest sports class. We assume, however, that gymnasts' COP sways noted on a force plate while maintaining body balance in an inversed position will show a significant correlation with the level of their training. Hitherto research on the ability to maintain body balance in a handstand have mainly been focused on the explanation of the most important factors determining the execution of the exercise itself from a methodical viewpoint [16, 17, 18].

There is little information on the posturographic evaluation at various stages of sports proficiency and its relationship to the efficiency of sports training. Therefore, the aim of the study was to determine the level of maintaining body balance in a handstand among gymnasts at the stage of directed and championship training and to demonstrate relationships with the sports result, taking into account the degree of difficulty and the quality of exercises.

MATERIAL AND METHODS

The study involved two groups of athletes training gymnastics. The first one were boys aged 11–12 years training at the directed stage (G1, n = 20), while the other group was composed of 12 experienced gymnasts aged 18–26 years with an accomplished master class (G2, n = 12). All the examined gymnasts had started sports training at the age of 5 or 6. Both groups comprised top athletes classified at the national and the international level. In terms of physical development, the junior group was characterised by the body height of 151.07 cm ±6.89 cm, body weight 39.84 kg ±5.41 kg and the BMI at 17.40 ±1.45. In the group of older athletes, the mean body height amounted to 172.14 ±4.45 cm, the body weight 70.90 ±3.61 and the BMI 23.93 ±0.85.

The study was conducted prior to the apparatus trial, on the day preceding competition in an official sports tournament. The trial of maintaining the body balance in a handstand was carried out in a closed room after about a 10-minute warm-up. In order to do this, anAccuGait force plate with AMTI BlanceClinic software was used. The handstand was performed with a technique of forcedstand from a supported forward bend. After a clear marking of the handstand on the plate, executed in consistence with the requirements of the International Gymnastics Federation [19], a measurement of pressure forces (Fx, Fy, Fz) and their moments (Mx, My, Mz) began, which lasted 10s with a frequency of 100Hz. This test was repeated three times at one-minute intervals. To analyse the tests results, the best result of the indicators was taken into consideration: the maximum COP sway in the transverse axis (X max), the maximum COP sway in the sagittal axis (Y max), the path length, and the area of the ellipse of the 95th percentile (Area 95).

An assessment of the effectiveness of sports training was made on the basis of judges' protocols from official sports competitions which took place the next day after testing the body balance in a handstand. The degree of difficulty and the quality of the performed exercises (mistakes in executing the exercises) in individual gymnastic events were taken into account. They were calculated in accordance with the current FIG provisions of scoring [19]; however, in the group of younger athletes they were modified by the State Training Commission of the Polish Gymnastics Association. The final result both in the older and the younger group was the sum of points for the difficulty and the quality of exercises in the all-around event.

Statistically insignificant results were obtained in the study of the normality of distribution of variables by means of the Shapiro-Wilk and the Kolmogorov-Smirnov tests. Hence, to determine the significance of differences between the two groups of gymnasts attempting to maintain static body balance in a handstand, a one-way ANOVA test was used. To specify a correlation of indicators of static body balance in a handstand with the level of sports preparation, a simple regression equation and Cohen's f^2 coefficient were applied.

RESULTS

Analysis of the mean values of the examined indicators of maintaining static body balance in a handstand showed significant differences between the studied groups of gymnasts (Figure 1 and Figure 2). The largest one was reported in relation to the Area 95, whose field among experienced athletes was less than half the size ($\bar{x}$ = 8.16 cm² ±8.06 cm²) of that in the younger group ($\bar{x}$ = 19.81 cm² ±8.74 cm²). Mean values of the indicator defining the COP path length were also significantly lower than in the younger group (G1, $\bar{x}$ = 111.74 cm ±17.30 cm; G2, $\bar{x}$ = 72.22 cm ±32.98 cm). The difference amounted to 39.52 cm, with the level of standard deviation being clearly higher in group G2 than among the younger gymnasts. In the indicator defining the maximum COP sway from the X axis of the centre of the plate (G1, $\bar{x}$ = 1.75 cm ±0.60 cm; G2, $\bar{x}$ = 0.97 cm ±0.46 cm), the difference between the mean values for the examined groups amounted to 0.78 cm and was significant at the level of $p < 0.001$. With respect to the Y axis, the difference was reported at 1 cm with $p < 0.001$ (G1, $\bar{x}$ = 3.03 cm ±0.44 cm, G2 $\bar{x}$ = 2.05 cm ±0.77 cm). Noteworthy is the fact that fluctuations in the transverse axis were clearly larger than in the sagittal one both among the younger and the older athletes.

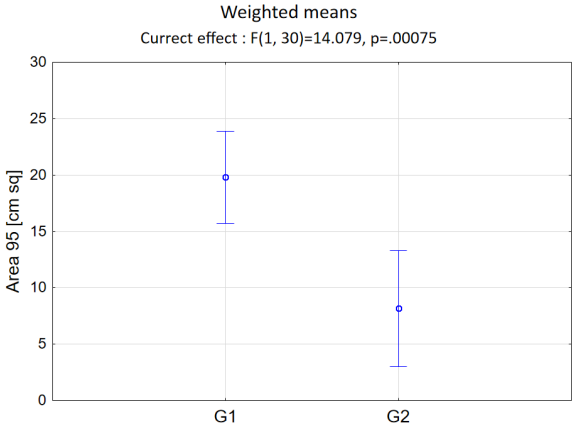

Fig. 1. Unweighted means of the Area 95 index in the younger and the older group with 0.95 confidence interval

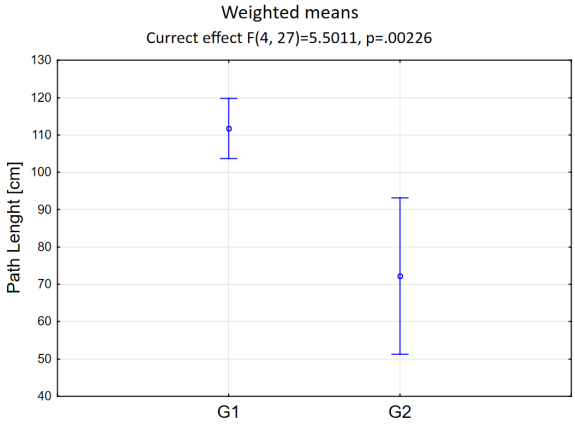

Fig. 2. Unweighted means of the Path Length index in the younger and the older group with 0.95 confidence interval

The obtained values of the difficulty, the quality and the final result in the gymnastics all-around event were not subjected to the test of the significance of differences because the routines performed by competitors in particular events were not assessed on the basis of the same criteria in both groups. The results of mean values taking into account the standard error are presented in Table 1.

Table 1. Mean values of indicators of the efficiency of sports training in the group of junior and senior gymnasts

Indicators of gymnasts' sports preparation		G1 (n-20)	G2 (n-12)
Difficulty of exercises	$\bar{x}$ sd	27.06 3.70	28.17 4.81
Quality of exercises	$\bar{x}$ sd	50.51 3.16	50.86 1.31
Final result	$\bar{x}$ sd	77.49 6.60	78.37 5.40

In a study of correlations of indicators of static body balance in a handstand with the efficiency of sports training of young gymnasts, the strongest correlation was noted between X max with the quality of the performed exercises in the all-around event (r = -0.538) and the sports result (r = -0.450). Also the indicator Area 95 showed close correlation values with the quality of exercises and the sports result (Table 2). The effects strength of statistically significant correlations was at the level of f^2 = 0.05–0.25. Maximum lateral sways and the COP path length had no significance in the presented results of sports training. It should also be added that none of the examined indicators of body balance in a handstand was significantly associated with the level of difficulty of the performed exercises.

Table 2. Regression results of indicators of body balance in a handstand with difficulty, quality and the final result of exercise performed in the younger and the older group of gymnasts

		Area 95 r value	Path Length r value	X max r value	Y max r value
G1 (n-20)	Difficulty of exercises in an all-around event	-0.235	-0.186	-0.319	-0.292
	Sports result in an all-around event	-0.450*	-0.254	-0.462*	-0.371
	Quality of exercises in an all-around event	-0.538*	-0.270	-0.560*	-0.362
G2 (n-12)	Difficulty of exercises in an all-around event	-0.755*	-0.748*	-0.699*	-0.667*
	Sports result in an all-around event	-0.712*	-0.725*	-0.694*	-0.637*
	Quality of exercises in an all-around event	-0.252	-0,277	-0.251	-0.166

*p < 0.05

In turn, in the group of experienced athletes, the correlation of the level of maintaining body balance in an inverted stance was significant with the difficulty and the final result of exercises in the gymnastic all-around event. The level of interdependence of all the analysed indicators of COP shifts with the difficulty and the sports result was similar and was running at the level of -0.637 to -0.755. The effect strength amounted to f^2 = 0.15–0.48. However, no significant correlations were noted between indicators of body balance in a handstand and the quality of the performed exercises.

DISCUSSION

The ability to maintain body balance is enumerated as one of the primary coordination components which determine the proper functioning of a human being. It occurs concurrently with other coordination skills, such as spatial orientation, movement differentiation and responsiveness. In a person's life it is a function of biological determination, whose level of expression largely depends on the volume and the characteristics of the impact of environmental factors [20]. The complexity of the issue of human body balance as a foundation for human motricity and one of the most important factors determining high athletic performance undoubtedly completes the difficulty and variety of its diagnostics. Despite many discussions, objectivity of such research is usually considered in a set of biomechanical, coordination and sensorimotor conditions [21]. The first of the above is subject to an assessment of the efficiency of the movement apparatus, mostly muscle strength, muscular tone and the range of motion. In the coordination sphere it most commonly refers to spatial-temporal accents of movement, i.e. the speed and the accuracy of execution, in conditions of movement replay and adaption. Finally, among the latter ones, sensitivity of sensory inputs responsible for information on positioning of the body and its individual parts are listed. Given the above determinants of body balance skills in a handstand, scientists agree that an ability to control this activity in terms of mobility of the wrist and the shoulder joints in the sagittal plane translates into the speed and the shift of the centre of gravity, and hence the body balance control [22]. Yeadon and Trewartha [23] also pay attention to delays in the response time of the vestibular-proprioceptive system between particular joints. It is emphasised that slight anteroposterior sways of in the shoulder joint are characteristic of gymnasts with a high degree of sports proficiency [24]. Among others, positions of the head, which plays adaptive functions due to changes in the sensory information, correlate with the efficiency of body balance in a handstand. According to Asseman and Gahery [25], the best stabilization of stance in a reversed position was noted in a standard positioning of the head (slight flexion) and in dorsiflexion (middle flexion) in relation to the longitudinal axis of the body. The level of maintaining body balance in a handstand is also determined by specific coordination skills. This is confirmed by a study of two groups of gymnasts similar in age which showed that the results of biofeedback tests with a moving target in a reversed position were to the advantage of top class athletes [26]. Similarly, experienced gymnasts achieved better results of body balance in a handstand with eyes opened and closed [27].

Comparing with other authors' analyses, the present research on body balance in a reversed stance has shown significant differences between experienced and inexperienced gymnasts. They were obvious in all the examined indicators. However, it should be noted that the compared research groups varied in terms of age and stages of training. In this case the younger group of gymnasts (at early adolescence) realised a sports training program aimed at teaching and perfecting basic gymnastics elements, where balance exercises with a gradual increase in the coordination complexity and the participation of the various manifestations of muscle strength constitute the basis for the majority of motor tasks. By contrast, exercises of the highest degree of coordination complexity in which participation of special strength abilities and the maximum power gradually increases dominate among older athletes (at the threshold of adulthood) who train at an advanced sports level. Signi-

ficant differences in the level of maintaining body balance in a handstand between the younger and the older group of athletes prove that this ability is largely affected by the influence of sports training. Attention is also drawn to much higher results of body balance in the transverse axis rather than the sagittal one in both groups. The differences between Y max and X max amount to 1.35 cm in younger gymnasts and 1.55 cm in older ones at $p < 0.001$. This data may confirm the importance of the mobility of wrist and shoulder joints in the sagittal plane in a strategy to maintain body balance in a handstand [22]. In the conducted analysis of correlations between body balance in a handstand and the level of sports preparation in the examined gymnasts one can notice that the indicator Area 95 has revealed significant correlations with the sports result in the all-around event in both the younger and the older group. In the group of younger gymnasts, significant correlations of selected balance indicators in a handstand with the assessment of the quality of the performed exercises have proved to be characteristic. Among senior athletes significant correlations were much more apparent with the degree of difficulty. In view of the fact that the conducted research is of a cross-sectional nature, it requires continuation and expansion in terms of the size and the number of athletes' age groups.

CONCLUSIONS

Analysis of correlations of body balance in a handstand with the level of sports preparation has helped demonstrate that the level of this skill specific to artistic gymnastics improves under the influence of sports experience and has great significance in shaping sports championship among both young gymnasts with a few years' experience and experienced athletes with the international class.

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