STATYCZNE I DYNAMICZNE TESTY RÓWNOWAGI U OSÓB TRENUJĄCYCH TAEKWONDO

STATIC AND DYNAMIC TESTS OF POSTURAL CONTROL IN TAEKWONDO CONTENDERS

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STRESZCZENIE

Równowaga dynamiczna i statyczna oceniania była u osób w wieku 19 do 27 lat, trenujących Taekwondo i w grupie kontrolnej, nieuprawiającej aktywności fizycznej. Równowaga statyczna była mierzona w czasie 20 s spokojnego stania na platformie stabilograficznej. Równowaga dynamiczna oceniana była przez 2,5 s po skoku na platformę i zeskoku z platformy. Nie stwierdzono znaczących różnic w równowadze statycznej pomiędzy grupami. W grupie osób uprawiających Taekwondo zmierzono mniejsze zmiany sił reakcji podłoża po skoku jednonożnym na platformę niż u osób nieuprawiających sportu, co dowodzi lepszej równowagi dynamicznej.

ABSTRACT

Static and dynamic postural stability was tested on a force plate between recreational Taekwondo athletes (TAE) and subjects who were not involved in any systematic sports activities (CON) aged 18 to 27 years. The static stability was measured in single- and double-leg 20 s quiet stance. The dynamic stability was assessed by the standard deviation of the ground vertical forces during 2.5 s period after landing in two tests: hopping and leaping on the force plate. The results revealed similar postural sway in TAE and in CON groups during a 20-sec quiet stance indicating that the traditional interpretation of stabilographic findings may be sometimes misleading in the assessment of postural performance in athletes. However, the vertical force variability that resulted from a single-leg hopping on the force plate was much lower in athletes than in controls.

Słowa kluczowe: sporty walki, wychwiania, równowaga, siła reakcji podłoża

Keywords: combat sports, sway, body balance, ground reaction force

1. Introduction

Fine postural stability is necessary to optimal performance of a majority of motor tasks and depends on the quality of the visual, vestibular and somatosensory inputs and their central integration [1, 2]. Persons having better postural balance willingly interact with challenging environment that promote complex variation in human movement as opposed to their less stable peers who are more cautious about being involved in unknown games or motor activities [3]. Not unexpectedly, the former attitude leads to fast acquisition of motor experience exhibited by a broad repertoire of motor strategies, while the latter one is a restricting factor in the overall motor development. It follows that the key factor in building adequate body stability is physical activity. Thus, the important goal in research into postural control is to elaborate specific forms of training or therapy aimed at improving or restoring body balance. Even moderate gains in balance may have astonishing effects on the global performance and will reward the trainees with faster picking up skills specific for the activity they have undertaken [4]. We believe that this relationship between postural and motor control is often underestimated by athletic trainers and the athletes themselves [5]. Amazingly, it is quite common that researchers and therapists draw inspiration from sports in their attempts to successfully ameliorate balance deficits in patients [6, 7].

Several sports have been reported to include athletes who possess exceptional body balance, e.g. gymnastics, dancing, soccer, or judo [4, 8, 9, 10, 11, 12]. The basic factor that helps to improve body balance in gymnastics and dancing are multiple repetitions in well-known environment. On the other hand, due to the unpredictable actions of the opponents, soccer and judo provide wide spectrum of different postural disturbances that make the two latter sports particularly suited to support fast balance improvement. However, there are other sports with similar characteristic, e.g. some martial arts that did not attract sufficient attention of researchers. One such sport, Taekwondo, seems very advantageous for developing postural control. It has been suggested that Taekwondo training improves postural control and general fitness, even among the amateur practitioners [13, 14].

Recently, Taekwondo as a sport's discipline coming from far East became very popular and many amateurs are training this martial sport art. There are several advantages of regular Taekwondo exercises. It was reported that it positively influences the bone density in young females and speeds up the development of sensory function [9, 15]. Some studies showed that profile of recreational Taekwondo athletes in terms of somatic type and body composition does not differ from those being in the elite group [16]. Therefore, one may assume that the body balance should not be dependent on the level of classification but rather results from the specific activity. The strength profile also is not characteristic for this discipline; however, it was reported that the coordination profile is discipline depending [17, 18]. Therefore, due to the limited knowledge of the potentially advantageous effect of Taekwondo exercises on postural control, further research is justified.

Leong et al. [13] pointed out the similarities in movement repertoire (frequent jumping and weight shifting) between Taekwondo, ballet and gymnastics. In a way, it might justify the expectation that Taekwondo training should lead to ameliorated postural sway as does training in the two latter sports. However, there are also important differences between these sports that may raise objections to such a hypothesis. Ballet and dancing require short yet demanding moments of sustained body balance as elements of performance evaluation. On the other hand, fine balance and postural control in Taekwondo is used mainly in the preparation for combat, and the ability to do it as fast as possible seems crucial for winning. A question arises: whether a skill in a brief dynamic postural control is transferable to static sustained stability?

The purpose of this study was twofold. First, we wanted to compare postural stability between Taekwondo amateurs and their non-training counterparts. As the traditional measures of static stability may have insufficient discriminative abilities, we supplemented these measures with dynamic tests that were supposed to evaluate better the specific postural skills in the athletes. We hypothesized that only the dynamic tests would confirm better balance in athletes than controls, while the less demanding static stability tests would likely show similar results in these two groups.

2. Materials and Methods

2.1 Participants

Seventeen healthy young people aged 18–27 years participated in the examination. Seven subjects were Taekwondo (TAE) contenders with at least five years training experience and ten subjects, who were not involved in any systematic sports activity, served as controls (CON). Informed written consent was obtained and the study was approved by the local ethical committee.

2.2 Experimental protocol

Postural control of examined subjects was investigated using two different tests that were conducted on two separate days and consisted of static and dynamic stability assessment, respectively. Static stability was assessed on a force platform in two 20-second tasks of quiet single-leg or two-leg stances. The subjects were asked to stand barefoot as motionless as possible with the feet together and the hands at sides. The subjects were instructed to focus their gaze on a dot placed at the eye level at a distance of 2 m. Each recording started 10 s after the subject was ready for testing in order to eliminate possible transients in the center of pressure (COP) time-series. To test dynamic stability the subjects were asked to perform two additional 4-second jumping tasks. The first task included hopping from the floor (the toe 10 cm away from the platform) onto the center of the platform. The initial and final position was unilateral standing on the no dominant (supporting) leg. The second task involved making a leap from one leg to the other while standing on the force platform. The knee of the non-supporting leg was pointing downwards and was bent at 90-degree angle. The subjects were instructed to do the test with minimal effort, yet some smoothness of movement was recommended. One researcher demonstrated this test twice to the participants to ensure the proper examination.

2.3 Data reduction

Data were recorded on a force plate (Kistler 9286 AA) at a sampling frequency of 100 Hz. The COP (the center of foot pressure) signal was calculated from the recorded ground reaction force in the medial-lateral (ML) and anterior-posterior (AP) plane separately. Static stability was evaluated by four parameters based on the COP signal: standard deviation (SD), range, mean speed (MV), and frequency (FR) [19]. Measures of COP variability and mean speed index postural performance whose poorer quality is associated with higher values of these indices. The COP frequency is thought to represent postural strategies and its higher value accounts for less competent postural control based on increased co-contraction of the antigravity muscles.

To evaluate dynamic stability the ground vertical forces (GVF) were analyzed. In many respects the time-course of these forces in hopping or leaping jumps should be similar to that occurring in the self-triggered drop test [13].

We hypothesized that the variability of these forces after eliminating transients that occur immediately following touchdown may be a plausible measure of postural control after a sudden disturbance to body stability. Lower variability would indicate either shorter time to achieve stability or a more tranquil overall postural behavior, both evidencing better postural control. The time course of the GVF oscillations starts with the first large maximum (challenge) and then produces a much lesser minimum (recovery), which is followed by a comfort zone where the amplitudes of the oscillations are promptly stabilized. From the recorded 4-second time-series the segments starting from the minimum in the recovery zone were extracted for further analysis. After obtaining such segments for all participants and tasks, the length of the shortest one was identified and all remaining segments were truncated to match this length by cutting off their end parts. The standard deviation of the GVF within these segments indicate dynamic stability.

The data were tested for normal distribution and homogeneity of variances. Due to not-normal distribution along with the small sample size, the non-parametric Mann-Whitney test was used to evaluate inter-group differences. The level of significance was set at $p < 0.05$.

3. Results

3.1 Static postural stability

The results concerning static stability in single- and double-leg stance are presented in table 1 and 2, respectively. None of the between-group differences for the computed sway parameters were significant, indicating similar postural performance in TAE and CON group.

Table 1. Means (S.D.) of the postural stability parameters in the Taekwondo contenders and controls in single-leg stance

	Medial/lateral plane		Antero/posterior plane	
	Taekwondo	Controls	Taekwondo	Controls
Variability [mm]	5.2 (1.1)	5.3 (0.7)	6.0 (1.4)	6.2 (1.3)
Range [mm]	26.7 (6.6)	28.2 (4.0)	32.2 (9.0)	33.6 (10.1)
Mean velocity [mm/s]	26.1 (8.0)	26.6 (5.7)	26.3 (8.1)	27.6 (5.4)
Frequency [Hz]	0.81 (0.18)	0.81 (0.19)	0.72 (0.22)	0.72 (0.15)

Table 2. Means (S.D.) of the postural stability parameters in the Taekwondo contenders and controls in double-leg stance

	Medial/lateral plane		Antero/posterior plane	
	Taekwondo	Controls	Taekwondo	Controls
Variability [mm]	4.0 (1.1)	3.6 (3.0)	4.7 (1.9)	3.9 (0.9)
Range [mm]	19.5 (6.0)	15.5 (9.5)	20.1 (5.8)	17.1 (3.0)
Mean velocity [mm/s]	8.9 (1.3)	8.5 (2.6)	10.7 (1.2)	10.1 (1.9)
Frequency [Hz]	0.38 (0.10)	0.50 (0.22)	0.42 (0.18)	0.44 (0.14)

3.2 Dynamic postural stability

An example of the GVF recorded in Taekwondo contenders and controls after hopping from the floor onto the platform is shown in Figure 1. The most apparent between-group differences took place in the recovery zone, between around 0.75 and 1.25 s following the minimum in the recovery zone. In contrast to one deep oscillation, which was recorded in CON within this half-second, the TAE produced two much more flat oscillations that indicated lower GVF amplitude and higher GVF frequency in the latter group. Another common difference between the GVF time-series in both groups was the value of the initial minimum. which was much lower in CON than in the TAE (see figure 1).

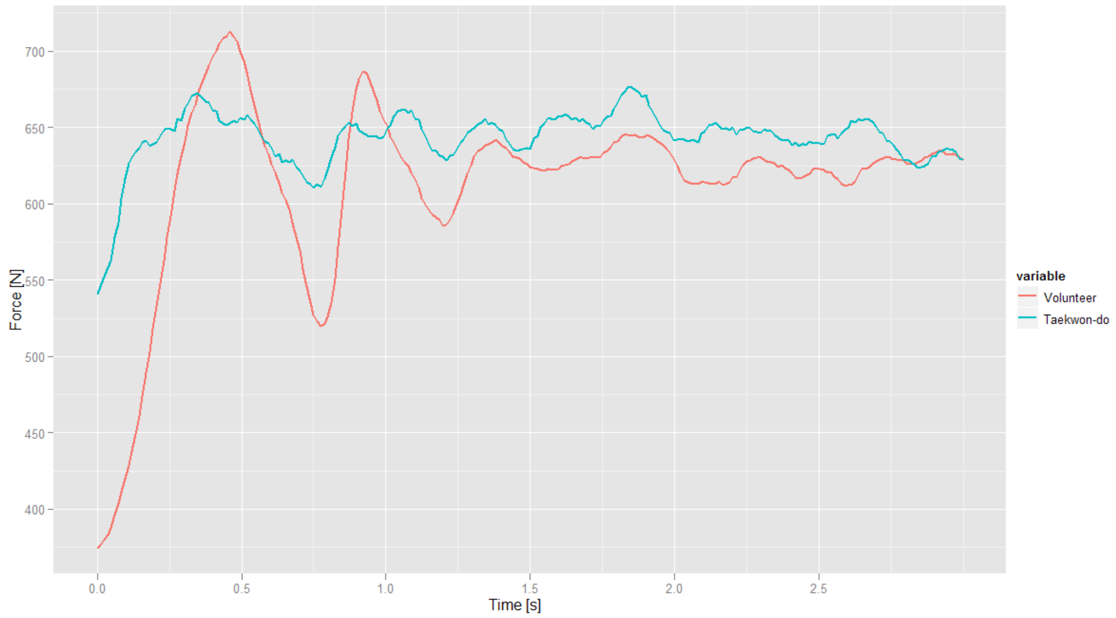

Fig. 1. A representative example of the vertical ground reaction forces recorded after hopping from the floor onto the center of the platform

This subjective visual evaluation was confirmed by the objective measure of postural behavior. The standard deviation of the GVF time-series computed within this 2.5 s interval (the shortest segment among all 4-second GVF recordings) was significantly ($p < 0.02$) lower in TAE (27.0 ± 8.4 N) than in CON (54.2 ± 24.9 N). The GVF recordings in the leaping test, though generally similar to those in hopping, failed to identify any differences between TAE and CON neither visually nor objectively.

4. Discussion

The purpose of this study was to identify possible differences in postural control between young adult Taekwondo contenders and not training control subjects in static and dynamic body equilibrium tests. As hypothesized, the discriminative power of these tests increased with their level of difficulty. In the standard 20 s tests in quiet stance there were no differences between our two groups. A typical obstruction to postural stability, which is commonly used in stabilography, i.e. the single-leg stance was not challenging enough to reveal any differences between examined groups. In the same vein, the less challenging dynamic test used in this study, i.e. the leaping on the plate, did not produce significant intergroup differences. Again, it seems not unexpected due to a relative simplicity of this test, which requires only minimal excursions of the centre-of-mass both in the vertical and horizontal direction. In contrast, the postural adjustments in Taekwondo, which precede attack and defense actions, need to anticipate much larger consequences in body configuration and the effect of impact forces on postural stability.

This lack of superiority in athletes in the leaping test and two static tests indicates that the specificity of Taekwondo training does not address itself to a motor skill necessary for the fine balance performance in 20 s quiet standing trials. These findings concur with the suggestion by Bressel et al. that the development of optimal balance depends on specific sensorimotor challenges rather than on general sport activity [8]. Our results also support those by Perrin et al. and Schmit et al. who reported the COP variability as an insufficient measure to distinguish balance skills in professional ballet dancers from controls [9, 12]. However, Schmit et al. found expected differences analyzing the nature of dynamic behavior of the COP that required relatively complex measures from nonlinear systems theory.

An alternative to sophisticated measures of sway is difficult experimental protocol that if properly designed, may be challenging enough to differentiate between the examined groups. From the two dynamic tests used in this study, only the hopping onto the force plate showed better control of the body stabilization after self-initiated disturbance in TAE than in CON. In fact, the mean value of the GVF variability during the measured 2.5 s period in athletes was two times lower comparing to controls. Although, the significance of the GVF variability is yet to be established and warrants further investigations, it seems plausible to interpret low values of this variability as a better skill of athletes to smoothly control the process of stabilization. We believe having, in mind the philosophy of Taekwondo fight that a major functional advantage of such a skill in TAE is a more efficient damping of transients in the recovery zone, which may significantly reduce the time to recover optimal equilibrium necessary for the consecutive move (e.g. kick). It concurs with the results of Leong et al. showing that the difference in the time to recover after the operator-triggered drop from 30 cm between the TAE and in untrained subjects was about 80 ms in favor of the TAE [13]. While we agree with the latter authors that this difference may be functionally important during combat fighting or challenging postural activities, identifying this difference alone does not shed light on possible control mechanisms that lead to faster body stabilization. In contrast, a more thorough analysis of the spatiotemporal structure of vertical forces after dynamic landings may help elucidate these mechanisms. For instance, the lower GVF standard deviation in TAE found in this study suggests that these athletes may use different stiffness strategy just following the touchdown. It is known from basic mechanics that higher stiffness leads to lower amplitude, however at the expense of higher frequency of oscillations. Nevertheless, this apparently less energy-efficient strategy may be an important adaptation acquired by the Taekwondo contenders to the conditions of combat. To better understand this adaptation further studies are required, in particular on the frequency content of the force time-series after touchdown.

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