



PROPRIOCEPTIVE ABILITY OF FENCING AND TABLE TENNIS PRACTITIONERS

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ABSTRACT

Purpose. The aim of the study was to compare the spatial component of proprioceptive ability by reproducing a upper limb movement typical in table tennis and fencing. **Methods.** The research comprised 41 young males of which 12 were table tennis players, 14 fencers, and 15 not involved in any competitive sports as a control. The experiment was based on assessing the precision of pronation and supination of the forearm at the elbow joint in recreating a set movement range by use of a goniometer. **Results and conclusions.** The results point to a higher level of proprioceptive ability in fencers and table tennis players than the control group but only in respect to the tasks executed with the dominant limb. This is inferred to be the result from the specific character of both sports (i.e. the intensive use of one limb and the consequent laterality of that limb) causing higher sensitivity and proprioception. This may provide a link between swordplay, table tennis, and the level of proprioception. The research methodology used herein may be useful in monitoring fencing training. Although not unequivocally statistically significant, the results indicate the potential for further research in this area.

Key words: proprioception, fencing, table tennis, joint position sense

Introduction

Achieving success in modern sports requires ever-increasing levels of peak physical and mental conditioning, hence the search for newer and more efficient training methods by sports practitioners and researchers [1]. Some researchers have suggested that one way to mobilize fitness potential without increasing strain is through the use of training methods that focus on developing motor coordination abilities such as the ability to kinesthetically differentiate movement and its ranges by way of proprioception [1]. The literature features research that stresses the significance of proprioception in sports yet also notes the complexity and variety of measuring standards due to various factors including difficulties in selecting the methods of assessing the motor skill in question [1, 2]. Nonetheless, the noted dependency between sporting excellence and proprioceptive ability has suggested that this factor should be taken into account during the recruiting process [3]. Lephart et al. [4] compared the accuracy of movement at the knee joint in gymnasts and a control group concluding that specific sports training had a positive influence on knee proprioception by creating enhanced neurosensory pathways in athletes. Similar findings showed that ice hockey players and ballet dancers presented significantly better results than a control group in proprioception of the foot and ankle complex and linked this result with their involvement in athletic activity [5]. When examining figure

skaters, Starosta et al. [3] found a mutual relationship between the level of proprioceptive sensitivity and athletic achievement, concluding that a higher achievement level is associated with greater proprioception in recreating a set range of movement. Other authors have pointed out the importance of developing sensorimotor perception in beginner swimmers as a base for further improvement [6].

The literature demonstrates that proprioceptive ability is better developed in those parts of the body directly involved in a given sport. Li and Huang [7] drew similar conclusions, finding basketball sharpshooters to exhibit a high level of motion sensitivity in finger and elbow flexors and a great degree of accuracy in choice reaction tasks. The results of Starosta [1] and Starosta et al. [3] may also indicate the particular significance of proprioceptive ability. In these bodies of work, it was found that the differentiation of movement in canoeists during the competitive season is much greater than in the preceding training season. In addition, a significant relationship between the level of proprioception, the results of a motor test, and technique was found [3]. Walaszek and Nosal [8] found that children practicing acrobatic rock'n'roll were characterized by a higher level of proprioception than a control group. Analysis of the relationship between the results of exercise tests and the precision of applying strength (proprioceptive sensitivity) concluded that research on proprioceptive sensitivity may be useful in monitoring training in numerous sports [2].

Proprioception of movement can be expressed in the selection, execution, or sensation of the position of in-

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dividual body parts (the spatial component), the muscle strength involved in the movement (the strength component), and the speed of the movement (the temporal component) [9]. According to Starosta [1], developing proprioceptive ability by initiating, refreshing, and acquiring kinesthetic awareness in the three above-mentioned components may increase training effectiveness. Some authors have emphasized the importance of specific exercises improving movement imagery and kinesthetic ability (based on creating kinesthetic experience) in improving and strengthening proprioception [10].

Table tennis and fencing are sports in which success depends on many interconnected factors, with motor coordination abilities indicated as the most important. Borysiuk [11] found that such abilities have a decisive effect in fencing, especially in the spheres of movement precision and motor adaptation. Czajkowski [12] also highlighted the significance of motor coordination in this sport, emphasizing the special role of time perception as a tactical option and the ability to take an opponent by surprise as an integral part of any bout. Similar conclusions on the significance of motor coordination were found in the literature on table tennis [13, 14].

However, little research has assessed the level and significance of proprioceptive ability in both sports, where the role of such features as sensing (sensing time, the table tennis ball, or weapon) are very important [12, 15]. Those few studies in the literature suggest that proprioceptive ability significantly affects technical skills and sporting success in table tennis [9, 13, 16]. These include skills such as selecting the paddle's position and angle, the selection and strength intensity of a stroke, and discerning the ball's rotation [9, 14]. In fencing, notions such as the sense of the weapon, distance, and pace have been analyzed [17]. Other aspects of particular significance include 'sensing the steel', sensing the position of the upper limb (forearm, arm, hand) when thrusting or controlling the weapon, directing thrusts towards the target area, movement precision when parrying, the speed at which the arm is straightened, and "sensing the steel" are of great significance [17]. Due to the fact that the skills related to effective proprioceptive ability seem important both in table tennis and fencing, it would be interesting to determine whether athletes involved in these sports display a high level of motor skills (measured by known and available methods). An answer in the affirmative would emphasize the significance of kinesthetic diversity in both sports and may prompt its inclusion and development in the training process. An assessment of the level of proprioceptive ability could also serve in monitoring training in fencing and table tennis.

Therefore, the aim of the study was to compare proprioceptive ability by recreating the position of upper limb movements typical in table tennis and fencing. This would include a search for all correlative relationships between the above factors. It was hypothesized

that a higher level of this ability in table tennis and fencing athletes than in untrained individuals may signify the importance of this factor in both sports, determine a link between athletic activity and the level of proprioceptive ability, and also signify the influence of specific training on how proprioceptive ability is shaped.

Material and methods

Research comprised young males at a similar age level. The sample included 12 table tennis players, 14 fencers, and 15 of their peers as a control. Measures of age, body height, and body mass of the examined groups are presented in Table 1.

Table 1. Basic descriptive characteristics of the examined groups for age, body height, and body mass

	Age (years)		Body height (cm)		Body mass (kg)	
	\bar{x}	<i>SD</i>	\bar{x}	<i>SD</i>	\bar{x}	<i>SD</i>
Table tennis (<i>n</i> = 12)	13.17	1.03	163.75	3.96	57.75	6.38
Fencing (<i>n</i> = 14)	12.64	0.74	158.57	8.11	49.43	7.35
Control (<i>n</i> = 15)	12.67	0.49	154.8	7.49	47.8	7.97

The fencers were members of a fencing club with about 3 years' competitive experience. Competitive experience in the case of the table tennis players was slightly longer at about 5 years. The control group comprised 15 boys from a local primary school not involved in any competitive sport.

Testing was performed with a goniometer to assess the precision of recreating a set movement range [3, 9]. The testing apparatus consisted of a specially constructed goniometric appliance to measure forearm pronation and supination at the elbow joint (Figure 1). It consisted of a stationary main body with a rotating cylinder attached to a handle in which the cylinder/handle rotated on a Teflon bearing. A revolving linear potentiometer fixed at the end of the cylinder recorded the angle of rotation. An analog-to-digital converter and Labview software ver. 2009 (National Instruments, USA) were used to digitally record the angular values when rotating the cylinder/handle.



Figure 1. Goniometer and subject positioning

Participants sat on a chair of adjustable height and held the handle of the appliance in such a way that the forearm and the upper arm formed a right angle. The elbow of the arm executing the movement was positioned touching the body (Figure 1). During the examination the forearm’s axis coincided with the axis of movement, while the capitulum of the third metacarpal bone coincided with the rotation axis in accordance with the requirements of the measured movement range.

The participants were not allowed to familiarize themselves with the appliance prior to testing. For the purpose of the test, participants were blindfolded and asked to execute a pronation movement with the dominant limb three times beginning from the start position of 0 and rotating the handle to an angle of 45°. Upon reaching the 45° angle a loud ring was automatically sounded. Immediately after completing the third try, the participants were asked to repeat the same movement five times but this time from memory (blindfolded with no audio cue) and to stop at the 45° angle. The above procedure was then repeated with a supination movement, and then repeated in full for the non-dominant hand.

The software recorded the maximum range of movement in each direction (pronation/supination) as the angle was reproduced by the subject. The subject’s starting position was confirmed before each attempt and adjusted by the researcher conducting the test. The time for repeating the five movements ‘from memory’ could not exceed 30 s. The extent of proprioceptive differentiation was determined for both the dominant and non-dominant limbs in the pronation and supination movements by calculating the precision rate, or the standard deviation of the recreated angular values, by the formula:

$$PR = \frac{\sum_{i=1}^5 x_i - \bar{x}^2}{5}$$

in which *PR* – precision rate, x_i – the value of the recreated angle of pronation or supination in i^{th} sample, \bar{x} – arithmetic mean of the recreated angles.

Precision rates were calculated for P-D (pronation of dominant limb), S-D (supination of dominant limb), P-ND (pronation of non-dominant limb), and S-ND (supination of non-dominant limb). A smaller precision rate was treated as an indicator of better proprioceptive ability (in more accurately recreating the spatial component of the movement in question). Statistical analysis of the acquired results was performed with Statistica software (Statsoft, USA). After basic descriptive statistics were calculated, between-group comparisons were made with the Kruskal–Wallis one-way analysis of variance and multiple comparisons of mean ranks for all groups.

Results

The purpose of the experiment was to assess the precision of recreating a pronation and supination movement of the forearm at the elbow joint by three groups: table tennis players, fencers, and a control group not involved in any competitive sports. The table tennis players acquired the lowest precision rates in recreating supination with the dominant limb and pronation with the dominant limb. These values were slightly higher in the case of the non-dominant limb (Table 2). It is interesting to note the high or average mean dispersion and variation of the results as evidenced by the standard deviations and interquartile ranges as well as the relatively average and high values of the coefficient of variation.

Table 2. Basic descriptive statistics of the precision rates in recreating pronation with the dominant limb (P-D), supination with the dominant limb (S-D), pronation with the non-dominant limb (P-ND), and supination with the non-dominant limb (S-ND) movements

	Variable	\bar{x} (°)	Me (°)	Min (°)	Max (°)	IQR (°)	SD (°)	CV (%)
Table tennis (<i>n</i> = 12)	P-D	5.44	4.68	1.59	8.75	4.93	2.55	47.00
	S-D	5.28	4.02 ^t	1.93	14.58	3.35	3.61	68.33
	P-ND	5.55	5.78	2.63	9.32	2.70	1.96	35.41
	S-ND	7.46	6.95	2.46	16.99	6.28	4.34	58.15
Fencing (<i>n</i> = 14)	P-D	4.84	4.60 ^t	1.60	8.28	3.45	2.03	42.00
	S-D	5.01	4.43 [*]	2.84	7.95	2.33	1.71	34.31
	P-ND	7.49	6.73	2.72	16.38	5.60	4.04	53.99
	S-ND	6.39	5.81	1.38	10.59	2.64	2.61	40.89
Control (<i>n</i> = 15)	P-D	7.61	7.71	2.51	17.99	4.74	3.99	52.47
	S-D	7.44	7.15	2.44	12.61	4.60	3.10	41.75
	P-ND	7.18	6.09	1.24	13.97	5.68	3.84	53.43
	S-ND	5.86	5.81	2.37	11.35	2.82	2.56	43.65

\bar{x} – mean, Me – median, Min – minimum, Max – maximum, IQR – interquartile range, SD – standard deviation, CV – coefficient of variation, * – difference from control at $p < 0.05$, t – difference from control group at $p < 0.10$

A similar distribution of the results and their values may be observed in the group of fencers. The arithmetic means and medians were slightly lower in the tests performed with the dominant limb than the non-dominant one (Table 2). Of interest is that the difference in performing the pronation movement was quite considerable. Analysis of the dispersion and variation of the results indicates smaller differentiation than in the table tennis group.

Analysis of the results in the control group revealed larger median and mean values in most of the analyzed movements compared with both groups of athletes (Table 2). Coefficients of variation and standard deviations in all four analyzed movements were similar and at an average level, signifying average intragroup differences.

Analysis also included comparing the precision rates obtained in the tested movements by all of the groups. As normal distributions were not found in some of the movements, intergroup differences were assessed using non-parametric tests. Comparison of the arithmetic means and medians found similar results between the table tennis players and fencers in virtually all four of the tested movements, with no statistical differences revealed by Kruskal–Wallis one-way analysis of variance. Precision rates obtained by the athletes were lower than the control group in movements performed with the dominant limb in both pronation and supination (a sign of better ability). Kruskal–Wallis one-way analysis of variance found a statistically significant difference ($H = 6.20, p = 0.0451$) only in supination of the dominant limb (S-D). The post-hoc multiple comparisons of mean ranks for all groups did not confirm a statistically significant difference, with p values of 1.00 between fencers and table tennis players, 0.15 between fencers and controls, and 0.07 between table tennis players and controls. No statistically significant differences between the athletes and the control group were observed in the tests performed with the non-dominant limb.

Discussion

This study analyzed the spatial component of proprioceptive ability, which involves sensing and differentiating the position of individual body parts, in this case, the position of the forearm at the elbow joint during a pronation and supination movement. The literature claims that the level of proprioceptive, or kinesthetic, sensitivity is the highest in parts of the body involved in a given sport. This was found to be the case in basketball players, who displayed greater sensitivity and a higher level of upper limb proprioception [7]. Arman et al. found that professional ballet dancers demonstrated greater accuracy than a control group in positioning upper and lower limb joints and hypothesized this to be the effect of improved proprioceptive response as a result of dance practice [18]. Other researchers have

also pointed out the significance of proprioceptive sensitivity in soccer as well as the connection between the level of proprioception and improved technique in karate [19, 20]. Rejman et al. [21] examined monofin swimmers and suggested that the high level of kinesthetic response in this group was the result of an adaptation prompted by the specificity of the additional sensory stimulus received in the form of feedback from the large surface area of the monofin.

Similar conclusions can be inferred by the results of the present study, although better movement execution by the two athlete groups was only observed in the dominant limb when compared with the control group. The table tennis players and fencers displayed lower mean and median precision rates than the control group for the dominant limb in the supination movement, albeit these differences were not unequivocally statistically significant as determined by post-hoc testing. This may suggest a relationship between the practice of swordplay and table tennis and the level of proprioceptive ability. The differences in executing these movements with the dominant limb may result from the specific character of both sports (hitting a ball with a paddle, holding and wielding a blade) being performed with the dominant limb. It is possible that practicing a sport that involves numerous repetitions of precise arm, forearm, hand, or finger movements may increase the proprioceptive sensitivity of the more frequently used limb, and may ‘solidify’ or ‘refresh’ kinesthetic sensation [1]. This may account for the better results (especially in the case of the fencers) in the supination movement. In the case of the non-dominant limb, the two athlete groups did not differ from the control group.

In table tennis, supination and pronation movements are performed to change the angle of the paddle [13]. In fencing, supination and pronation movements at the elbow joint are characteristic during parrying, especially in the Quarte (parry 4) and Sixte (parry 6) [17]. The results of the present study may corroborate the extensive use of these types of parries in training and competition by the examined fencers, while at the same time, give rise to the use of the research methodology herein to monitor training progression.

Studies on proprioception have indicated that athletes are characterized by greater proprioceptive differentiation than individuals not involved in any sports [4, 8, 18]. This difference between a trained and untrained population was explained by the specificity of the practiced sport. However, these differences may in fact result from the development of proprioceptive ability during the training process typical of a given sport. In addition, a higher level of this ability may also result from the general recruitment and selection criteria of a given sport, as evidenced by the relationship found between proprioceptive ability and skill level [1, 3, 22].

In regards to the previously cited works, there are also reports that have indicated a lack of a clear difference

in reproducing movements between athletes and untrained individuals. Jerosh et al. [23] compared female table tennis players with a control group finding no differences in the accuracy of reproducing movements at the elbow joint. The differences in the results of studies on proprioceptive ability may attest to its large variability and dependence on numerous factors as well as the use of different measurement methods assessing its level. Some researchers have suggested that the components (strength, spatial, and temporal) of proprioceptive ability are relatively independent of each other, that no inherent relationship exists with the age of an athlete, and that data collected on this ability is highly variable. Instead, it is believed that the level of each individual component depends on physical and mental health as well as the level of motivation [24, 25].

Conclusions

1. The results point to a higher level of proprioceptive differentiation in fencers and table tennis players than in the control group although only for movements executed by the dominant limb. This may be the result of the specific character of both sports, i.e. the intensive use of one limb, and may therefore provide a link between swordplay, table tennis and proprioceptive ability. Although not unequivocally statistically significant, the results indicate the potential for further research in this area.

2. The fencers and the table tennis players executed the task of forearm supination (by the dominant limb) better than the control group and is believed to originate from the use of this movement in both sports. It can be considered that the research methodology used herein may serve in monitoring training progress in these sports.

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