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Research Paper

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## The Effect of Taekwondo Training on Static and Dynamic Balance Development: A Brief Review

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### ABSTRACT:

The successful performance of most daily activities and maintaining proper posture depends on the ability to balance, and the concept of balance is of great importance in daily life and in all sports branches. Taekwondo is characterized by an emphasis on dynamic kicking techniques applied from a moving stance. When practicing taekwondo techniques, a developed ability of static and dynamic balance during training and competition is extremely important in maintaining posture and making the right move in attack and defense. For these reasons, static and dynamic balance development is emphasized in taekwondo. In the literature, studies examining the effects of taekwondo training on various physical parameters were frequently found. Therefore, it was deemed necessary to summarize whether taekwondo training has an effect on balance ability in terms of the studies conducted in the literature. The aim of this study is to systematically examine the studies conducted to determine the effect of taekwondo training on balance development and to provide a source for further research on this subject.

**Keywords:** Taekwondo, Balance, Posture, Postural Control

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## 1. Introduction

Taekwondo, which dates back 1500 years, is one of the oldest martial arts styles in the world. Modern taekwondo is a combination of unarmed fighting styles originating from the Korean peninsula. In the last half century, the popularity of taekwondo has increased and has probably become the most widely practised martial art in the world (Lystad, Graham, & Poulos, 2013; Kukkiwon, 2024). Taekwondo is characterised by an emphasis on dynamic kicking techniques applied from a moving stance position. Technically, taekwondo is a type of self-defence that involves the skilful application of techniques involving punching, kicking, blocking, dodging, parrying with hands and feet. Therefore, performance in taekwondo can be determined by the technical, tactical, psychological, physical and physiological characteristics of a competitor. From a physical conditioning perspective, the aim of taekwondo training is to prepare competitors to effectively manage both the physical activity and physiological demands of fighting. The physical activity and physiological requirements of taekwondo competitions require athletes to be competent in various aspects of fitness, including aerobic and anaerobic power, muscular strength, muscular power, flexibility, speed and agility (Bridge et al., 2014). These qualities are important characteristics for a taekwondo athlete to be able to execute highly demanding kicking combinations (Lystad, Graham, & Poulos, 2013). In addition, balance (static and dynamic) along with flexibility plays an important role in protecting players from injuries and technically successful tactical performance. Therefore, it is important for physiotherapists and coaches to conduct objective studies on the balance characteristics of athletes and to determine a training targeting these characteristics (Yeole & Shah, 2020).

Balance or postural control is the process of maintaining the position of the body's centre of gravity vertically stable on the base of support by executing coordinated neuromuscular activities with information from the visual, vestibular and somatosensory systems by receiving rapid and continuous feedback (Nashner, 2014). The concept of balance is of great importance in daily life and in all sports branches. The successful realisation of most of the daily activities and ensuring proper posture depend on the ability of balance. In athletes and sedentary individuals, the neuromuscular system quickly adapts to the changes of the centre of gravity during rest and movement (Akyüz, Çoban, Dilber, Ergün, Taş, Işık, Akyüz, 2016). It has been reported that sports training, especially fast and highly skilful movements, improves one's postural control ability. Balance training has long been used to prevent injuries and to restore proprioception and kinesthetic skills after injury. Recent research has shown that balance and mobility training play a critical role in improving athletic performance. It has been suggested that when properly directed, balance and mobility training can improve the body's movement awareness in all ranges of movement and this development can form the basis of general sporting abilities in sports branches (Clark, Lucett, Corn, 2008). One of the most commonly used skills in the routine practice of TKD is the roundhouse kick (Falco et al., 2009). Other widely used techniques include side kick, back kick and spinning kick (Pieter and Heijmans, 2000). Body rotation and balance while turning on one leg is an important component in all these kicking skills. Previous studies have shown that elite TKD athletes are able to turn and kick at high speeds (5.2 m/s to 16.26 m/s) and generate a large amount of striking force (390.7N to 661.9N) without losing balance (Pieter and Pieter, 1995; Lee et al., 2008). In addition to turning and kicking, TKD practitioners often adjust their body position and distance from the opponent by stepping in different directions during competitions to score points. Steps are typically taken before attacks to surprise the opponent, while some movements are also made before defensive manoeuvres to get out of the line of attack (Pieter and Heijmans, 2000). Therefore, it is reasonable to assume that TKD practitioners may have developed specialised balance skills during turning and stepping to avoid falling and losing points during competitions. Maintaining body balance during turning and stepping is crucial not only for

maximising sport performance, but also for many daily activities (Fong et al., 2010; NeuroCom, 2008). For these reasons, whether the balance ability, which is of great importance in this branch, improves with the effect of taekwondo training has been the subject of many studies. In this study, it was deemed necessary to summarise the effects of taekwondo training on static and dynamic balance in the literature.

## 2. Method

This study includes a systematic investigation of the studies conducted to determine the effect of taekwondo training on balance development. Within the scope of the study, various academic databases were searched in order to identify scientific studies evaluating the effects of taekwondo training on balance. Appropriate keywords and controlled terms were used in the search process using various databases such as PubMed, Google Scholar, Web of Science and Scopus. These terms include terms such as "taekwondo", "balance", "posture", "postural control". The articles obtained as a result of the search were selected among those compatible with the purpose of the study. The selection criteria included experimental studies examining the effect of taekwondo training on balance development and studies with control groups. In addition, no language restriction was made. The 16 articles selected in accordance with the purpose of the study cover the period between 2002 and 2023. The findings are presented by summarising and synthesising previous research describing the effects of taekwondo training on balance.

## 3. Results

Research shows that Taekwondo athletes have superior balance abilities compared to non-taekwondo athletes (Fong, 2010; Dijk, 2015). This is attributed to the sport's emphasis on dynamic footwork and kicking techniques that require special balance skills. Taekwondo training has been found to improve balance, coordination and cognitive functions in children, young, middle-aged and elderly individuals (Brudnak, Dundero, & Van Hecke, 2002; Çiçek & Türkeri, 2023; Dijk, 2015; Fong & Ng, 2012; Pathare et al., 2018; Şahin, 2017). In addition, dynamic postural control activities have been shown to be effective in improving balance in amateur Taekwondo players (Yeole, 2020). These findings emphasise the important role of Taekwondo in the development and maintenance of balance abilities. In this section, studies examining the effect of taekwondo training on balance development and their results will be summarised.

Table 1. Literature results on the effect of taekwondo training on balance performance

Study	Country	Age: Mean $\pm$ SD (years)	Sex	Groups (n)	Test	Duration	Results
Fong & Ng (2012)	Hong Kong	EG <sub>1</sub> : 13.4 $\pm$ 0.8 EG <sub>2</sub> : 12.9 $\pm$ 1.2	F/M	EG <sub>1</sub> : 11 EG <sub>2</sub> : 11	Unilateral Stance Test (UST) Sensory Organization Test(SOT)	-	Athletes who performed TKD for 5-9 years and 1-4 years showed better balance performance compared to the control group.

		CG:1 2.3±1. 3		:1 0 C G: 10			
Fong et al. (201 2)	H on g K on g	EG: 15.58 ±1.07 CG:1 6.21± 0.98	F / M	E G: 19 C G: 19	Forward Lunge Test Step/Quick Turn Test	-	It was observed that Tkd athletes had better postural control than the control group.
Path are et al. (201 8)	U S A	F: 7.9±2. 3 M: 8.7±1. 4	F / M	17	Balance tests	10 weeks TKD training	Improvements were seen in bipedal and tandem postures in underweight and obese children.
Çiçe k&T ürker i (202 3)	Tu rk ey	EG <sub>1</sub> : 8.7±0. 48 EG <sub>2</sub> :8 .2±0.4 2 CG:9. 5±0.5 2	F / M	E G <sub>1</sub> : 10 E G <sub>2</sub> : 1 0 C G: 10	Y Balance Test	8 weeks (TKD and gymnast ic training	Taekwondo training was found to have a positive effect on balance.
Patti et al. (201 8)	Ita ly	EG <sub>1</sub> : 11.1± 4.8 EG <sub>2</sub> :1 0.5±2. 6	-	E G <sub>1</sub> : 1 1 E G <sub>2</sub> : 1 8	Posturograph y Test	-	It was found that taekwondo athletes exhibited better balance performance compared to tennis athletes.
Tem ur et al. (202 2)	Tu rk ey	F: 12.0± 1.56 M: 12.8± 1.13	F / M	E G <sub>1</sub> : 15 E G <sub>2</sub> : 1 5 E G <sub>3</sub> : 1 5	Flamingo Static Balance Test	-	It was found that the static balance times of athletes trained in skiing and taekwondo were better than those trained in basketball.

Şahin (2017)	Turkey	EG:18,20±1,96 CG:20,30±1,81	E G <sub>1</sub> :20 C G:20	Flamingo Static Balance Test Star Balance Test	-	It was found that athletes showed better balance performance than sedentary people.
Leonget al. (2011)	China	EG:20.9±1.5 CG:24±3.8	F / M E G:11 C G:11	Sensory Organization Test(SOT) Drop Test	-	Balance performance of individuals who performed TKD training was found to be higher than those not performing TKD training.
Farrahet al. (2020)	Iran	EG:23.63±0.91 CG:2.47±0.42	F E G:8 C G:8	Electromyographic Device	8 weeks	Functional TKD training on soft surfaces was found to improve balance in female athletes.
Dijk (2015)	Netherlands	F:52±6.7 M:59.08±5.56	F / M F:12 M:12	Single Leg Stance Test One Leg Hop Test	1 year	It was concluded that age-adapted TKD training improved various components of balance control.
Brudnak et al. (2002)	USA	Mean:71(Max:81, Min:63)	- N:27	Single Leg Stance Test	17 weeks	An increase was found in the balance skills of the participants after TKD training.
Cromwell et al. (2007)	USA	EG:72.7±6.1 CG:73.8±7	F / M E G:20 C G:20	Single Leg Stance Test Walking Measures Tests	11 weeks	Significant improvements were observed in balance and walking parameters in the taekwondo group.
Fong et al. (2013)	Hong Kong	EG:7.6±1.3 CG:7.2±1	F / M E G:21 C G:23	Unilateral Stance Test (UST) Motor Control Test (MCT)	3 months	It was observed that children with DCD who received intensive TKD training showed improvements in static one-leg balance control, but not in reactive balance control.
Kim et al. (2016)	USA	EG:10.25±2.38 CG:1.00±2.83	F / M E G:8 C G:6	Single Leg Stance Test Double Leg Stance Test Step/Quick Turn Test	8 weeks	In children with autism spectrum disorder, it has been observed that TKD application provides improvements in postural control.

Gürkan (2013)	Turkey	EG <sub>1</sub> :2 4.64± 6.4 EG <sub>2</sub> :2 2.36± 3.72 CG:1 8±0.6 6	M	E G <sub>1</sub> : 11 E G <sub>2</sub> : 1 C G: 10	Static Postural Balance Test	-	It has been observed that regular exercises contribute to the development of balance in hearing impaired people.
Carte r&Horvat (2016)	USA	EG:24 .25±3. 19 CG:2 5.90± 3.33	F / M	E G: 22 C G: 22	Clinical Test of Sensory Interaction on Balance (mCTSIB) Humac Balance Board Limits of Stability test (LOS)	10 weeks	No significant improvement was observed in static and dynamic balance values in the experimental group after TKD training.

#### 4. Discussion

Findings from various studies emphasise the important effect of Taekwondo (TKD) training on balance and postural control in different age groups and populations. TKD is known for its fast kicking techniques and athletes are faced with numerous positions that require them to stand on one leg during training and competition (Pieter & Heijmans, 2000). As emphasised by Pieter and Heijmans (2000), the importance of unilateral postural stability for TKD athletes is evident in the results of many studies. The study by Fong and Ng (2012) underscores the superior balance performance of young TKD practitioners compared to non-practitioners, attributing this to the repetitive kicking practices inherent in TKD training. The observation that experienced athletes rely more on their vestibular systems for balance, while less experienced athletes depend on visual and vestibular inputs, suggests a potential progression in balance strategy with increased training duration.

Moreover, the improved postural control during dynamic activities, such as the step-fast-turn test (Fong et al., 2012), further corroborates the benefits of TKD training. This enhancement in functional balance performance may be due to neurophysiological adaptations resulting from the sport's demands on somatosensory and vestibular systems (Leong et al., 2011). The superior sensory information processing and coordination in TKD practitioners compared to non-practitioners (Perrin et al., 1998; Borysiuk & Waskiewicz, 2008) emphasize the sport's role in refining these capabilities. Interestingly, Pathare et al. (2018) found that TKD training can positively impact postural sway in both healthy and underweight/obese children, with more significant improvements observed in lean/obese children. This suggests that TKD training may be particularly beneficial for improving balance in populations with diverse body compositions.

The comparative study by Çiçek and Türkeri (2023) reveals that while both gymnastics and TKD training enhance balance parameters, gymnastics training appears to have a more pronounced effect. This could be due to the different demands and techniques involved in each

sport, with gymnastics possibly providing more comprehensive balance challenges. In younger athletes, Patti et al. (2018) demonstrated that TKD athletes exhibit greater stability and reduced center of pressure oscillations compared to tennis athletes, likely reflecting the balance requirements of TKD. Similarly, Temur et al. (2022) found that TKD and skiing athletes had better static balance times than basketball players, indicating that sports with higher balance demands can lead to superior balance performance.

Among elite male TKD athletes, the significant improvements in static and dynamic balance compared to sedentary individuals (Şahin, 2017) highlight the sport's effectiveness in enhancing balance control. Leong et al. (2011) also emphasized that TKD training improves reliance on somatosensory and vestibular inputs for balance, which has implications for rehabilitative practices.

In older adults, studies by Dijk (2015), Brudnak et al. (2002), and Cromwell et al. (2007) consistently show that age-adapted TKD training can improve various aspects of balance, making it a viable exercise option for enhancing balance and preventing falls in the elderly. The improvements observed in balance and gait parameters suggest that TKD can help maintain mobility and function, which often decline with age.

For disadvantaged individuals and those with developmental disorders, TKD training has shown promising results. Fong et al. (2013) found improvements in static balance control among children with developmental coordination disorder after intensive TKD training, although reactive balance control did not show significant changes. Kim et al. (2016) demonstrated that TKD training can effectively improve balance in children with autism spectrum disorder, indicating its therapeutic potential. Similarly, Gürkan (2013) observed positive balance developments in hearing-impaired individuals, further supporting the inclusivity of TKD training benefits.

However, not all studies show significant improvements. Carter and Horvat (2016) found no notable changes in balance among young adults with Down syndrome following TKD training, suggesting that the effectiveness of TKD on balance may vary across different populations and require tailored approaches.

In conclusion, the collective findings from these studies highlight the positive impact of TKD training on balance and postural control across various populations. While TKD training appears to benefit individuals of all ages and abilities, the extent of its effects may vary depending on specific characteristics and needs of the participants. Further research is warranted to explore the underlying mechanisms and to optimize training protocols for maximizing balance improvements in diverse populations.

## **5. Conclusion**

The analysis of various studies on the effects of Taekwondo (TKD) training on balance abilities reveals consistent evidence supporting its positive impact across different age groups and populations. TKD training has been shown to enhance both dynamic and static balance in children, adolescents, middle-aged, and elderly individuals. Specifically, young TKD practitioners exhibit improved static and dynamic balance, increased unilateral postural stability, better postural control, and enhanced trunk and limb coordination (Borysiuk & Waskiewicz, 2008; Fong et al., 2012; Fong & Ng, 2012; Leong et al., 2011; Pathare et al., 2018; Perrin et al., 1998).

In middle-aged and elderly populations, TKD training effectively improves various aspects of balance control and gait patterns, indicating its potential as a valuable exercise for enhancing balance and walking skills in older adults (Brudnak, Dundero, & Van Hecke, 2002; Cromwell, Meyers, Meyers, & Newton, 2007; Dijk, 2015). This is particularly significant given the increased risk of falls and balance-related issues in this age group. Furthermore, TKD training

has demonstrated benefits for disadvantaged individuals, including those with developmental coordination disorders, autism spectrum disorder, and hearing impairments. It has been found to improve static balance and serve as a feasible, enjoyable, and effective therapeutic option for these populations (Fong et al., 2013; Gürkan, 2013; Kim et al., 2016).

Overall, the findings suggest that TKD training is a versatile and effective means of enhancing balance abilities across a wide range of populations. Its benefits extend from injury prevention to rehabilitation, making it a valuable addition to physical training and therapeutic programs. Future research should continue to explore the underlying mechanisms of these benefits and further refine training protocols to maximize the positive outcomes of TKD training on balance and postural control.

## 6. References

1. Akyüz, Ö., Çoban, C., Dilber, A. O., Ergün, Z., Murat, T., Özkan, I., ... & Akyüz, M. (2016). İşitme engellilerde statik denge düzeylerinin belirlenmesi. *Gaziantep Üniversitesi Spor Bilimleri Dergisi*, 1(2), 110-116.
2. Aydın, T., Yildiz, Y., Yildiz, C., Atesalp, S., & Kalyon, T. A. (2002). Proprioception of the ankle: a comparison between female teenaged gymnasts and controls. *Foot & ankle international*, 23(2), 123-129. <https://doi.org/10.1177/107110070202300208>
3. Borysiuk, Z., & Waskiewicz, Z. (2008). Information processes, stimulation and perceptual training in fencing. *Journal of Human Kinetics*, 19(2008), 63-82.
4. Bridge, C. A., Ferreira da Silva Santos, J., Chaabène, H., Pieter, W., & Franchini, E. (2014). Physical and physiological profiles of taekwondo athletes. *Sports medicine (Auckland, N.Z.)*, 44(6), 713–733. <https://doi.org/10.1007/s40279-014-0159-9>
5. Brudnak, M. A., Dundero, D., & Van Hecke, F. M. (2002). Are the 'hard' martial arts, such as the Korean martial art, TaeKwon-Do, of benefit to senior citizens?. *Medical hypotheses*, 59(4), 485–491. [https://doi.org/10.1016/s0306-9877\(02\)00203-7](https://doi.org/10.1016/s0306-9877(02)00203-7)
6. Carter, K., & Horvat, M.A. (2016). Effect of Taekwondo Training on Lower Body Strength and Balance in Young Adults with Down Syndrome. *Journal of Policy and Practice in Intellectual Disabilities*, 13, 165-172. <https://doi.org/10.1111/jppi.12164>
7. Clark, M. A., Lucett, S., & Corn, R. J. (2008). *NASM essentials of personal fitness training*. Lippincott Williams & Wilkins.
8. Cromwell, R. L., Meyers, P. M., Meyers, P. E., & Newton, R. A. (2007). Tae Kwon Do: an effective exercise for improving balance and walking ability in older adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 62(6), 641-646. <https://doi.org/10.1093/gerona/62.6.641>
9. Çiçek, İ., & Türkeri, C. (2023). İlkokul Öğrencilerine Uygulanan Cimnastik ve Taekwondo Antrenmanlarının Denge, Esneklik ve Sıçrama Parametrelerine Etkisi. *Spor Bilimleri Araştırmaları Dergisi*, 8(3), 399-414. <https://doi.org/10.25307/jssr.1215446>
10. Pons van Dijk, G. (2015). Taekwondo and physical fitness components in middle-aged healthy volunteers the Sekwondo study. [Doctoral Thesis, Maastricht University]. Maastricht University. <https://doi.org/10.26481/dis.20151029gp>
11. Falco, C., Alvarez, O., Castillo, I., Estevan, I., Martos, J., Mugarra, F., & Iradi, A. (2009). Influence of the distance in a roundhouse kick's execution time and impact force in Taekwondo. *Journal of biomechanics*, 42(3), 242-248. <https://doi.org/10.1016/j.jbiomech.2008.10.041>
12. Farrash, F. F., Sheikhhoseini, R., & Babakhani, F. (2020). Effect of Eight-Week Functional Exercise on Soft Surfaces on the Balance and Electromyographic Activity of the Muscles of Female Taekwondo Athletes. *Women. Health. Bull.* 2020;7(2):19-25.



13. Fong, S. M., & Ng, G. Y. F. (2010). The effect of taekwondo training on balance and sensory performance in young adolescents. *Hong Kong Physiotherapy Journal*, 1(28), 24. <https://doi.org/10.1016/j.hkpj.2010.11.010>
14. Fong, S. S. M., Cheung, C. K. Y., Ip, J. Y., Chiu, J. H. N., Lam, K. L. H., & Tsang, W. W. N. (2012). Sport-specific balance ability in Taekwondo practitioners. *Journal of Human Sport and Exercise*, 7(2), 520-526. <https://www.redalyc.org/articulo.oa?id=301023548002>
15. Fong, S.S., & Ng, G.Y. (2012). Sensory integration and standing balance in adolescent taekwondo practitioners. *Pediatric exercise science*, 24 1, 142-51. <https://doi.org/10.1123/pes.24.1.142>
16. Fong, S.S., Chung, J.W., Chow, L.P., Ma, A.W., & Tsang, W.W. (2013). Differential effect of Taekwondo training on knee muscle strength and reactive and static balance control in children with developmental coordination disorder: a randomized controlled trial. *Research in developmental disabilities*, 34 5, 1446-55. <https://doi.org/10.1016/j.ridd.2013.01.025>
17. Gürkan, A. C. (2013). İşitme engelli elit erkek sporcuların statik denge değerlerinin karşılaştırılması, [Doktoral Thesis], Gazi University.
18. Hausdorff, J. M., Rios, D. A., & Edelberg, H. K. (2001). Gait variability and fall risk in community-living older adults: a 1-year prospective study. *Archives of physical medicine and rehabilitation*, 82(8), 1050-1056. <https://doi.org/10.1053/apmr.2001.24893>
19. Ishiyama, G. (2009). Imbalance and vertigo: the aging human vestibular periphery. In *Seminars in neurology* (Vol. 29, No. 05, pp. 491-499). © Thieme Medical Publishers. <https://doi.org/10.1055/s-0029-1241039>
20. Kazemi, M., Waalen, J., Morgan, C., & White, A. R. (2006). A profile of Olympic taekwondo competitors. *Journal of sports science & medicine*, 5(CSSI), 114.
21. Kim, Y., Todd, T., Fujii, T., Lim, J. C., Vrongistinos, K., & Jung, T. (2016). Effects of Taekwondo intervention on balance in children with autism spectrum disorder. *Journal of exercise rehabilitation*, 12(4), 314–319. <https://doi.org/10.12965/jer.1632634.317>
22. Kukkiwon: World Taekwondo Headquarters. <http://www.kukkiwon.or.kr/eng/>
23. Lee, J. H., Lee, Y. S., & Han, K. H. (2008). A study on impact analysis of side kick in Taekwondo. *International Journal of Modern Physics B*, 22(09n11), 1760-1765. <https://doi.org/10.1142/S0217979208047389>
24. Leong, HT., Fu, S.N., Ng, G.Y.F. et al. (2011). Low-level Taekwondo practitioners have better somatosensory organisation in standing balance than sedentary people. *Eur J Appl Physiol* 111, 1787–1793. <https://doi.org/10.1007/s00421-010-1798-7>
25. Lystad, R. P., Graham, P. L., & Poulos, R. G. (2013). Exposure-adjusted incidence rates and severity of competition injuries in Australian amateur taekwondo athletes: a 2-year prospective study. *British journal of sports medicine*, 47(7), 441-446. <https://doi.org/10.1136/bjsports-2012-091666>
26. Nasher, L. M. (1997). Practical biomechanics and physiology of balance, from *The Handbook of Balance Function Testing*, Lewis M. Nasher. Mosby-Year Book, Inc, GP Jacobson, CW Newman, JM Kartush.
27. Nashner, L. M. (2014). Practical biomechanics and physiology of balance. *Balance function assessment and management*, 431.
28. Paillard, T., Noe, F., Riviere, T., Marion, V., Montoya, R., & Dupui, P. (2006). Postural performance and strategy in the unipedal stance of soccer players at different levels of competition. *Journal of athletic training*, 41(2), 172.
29. Pathare, N.C., Kimball, R., Donk, E., Kennedy, K.W., & Perry, M. (2018). Physical performance measures following ten weeks of taekwondo training in children: A pilot

- study. *International Journal of Physical Education, Fitness and Sports*. <https://doi.org/10.26524/ijpefs183>
30. Patti, A., Messina, G., Palma, R., Barcellona, M., Brusa, J., Iovane, A., & Palma, A. (2018). Comparison of posturographic parameters between young taekwondo and tennis athletes. *Journal of Physical Therapy Science*, 30(8), 1052-1055. <https://doi.org/10.1589/jpts.30.1052>
  31. Perrin, P., Schneider, D., Deviterne, D., Perrot, C., & Constantinescu, L. (1998). Training improves the adaptation to changing visual conditions in maintaining human posture control in a test of sinusoidal oscillation of the support. *Neuroscience letters*, 245(3), 155-158. [https://doi.org/10.1016/S0304-3940\(98\)00208-0](https://doi.org/10.1016/S0304-3940(98)00208-0)
  32. Pieter, F., & Pieter, W. (1995). Speed and force in selected taekwondo techniques. *Biology of sport*, 12, 257-266.
  33. Pieter, W., Heijmans, J. (2000). *Scientific Coaching for Olympic Taekwondo*. 2nd ed. Aachen: Meyer and Meyer Sport.
  34. Rubenstein, L. Z., & Josephson, K. R. (2002). The epidemiology of falls and syncope. *Clinics in geriatric medicine*, 18(2), 141-158. [https://doi.org/10.1016/S0749-0690\(02\)00002-2](https://doi.org/10.1016/S0749-0690(02)00002-2)
  35. Simmons, R. W. (2005). Sensory organization determinants of postural stability in trained ballet dancers. *International journal of neuroscience*, 115(1), 87-97. <https://doi.org/10.1080/00207450490512678>
  36. Şahin, M. (2017). *Elit erkek taekwondocular ve sedanterlerin statik ve dinamik denge değerlerinin karşılaştırılması [Master's thesis]*, Selçuk University.
  37. Temur, H. B., Gürbüz, C., Doğan, R., Karakulaklı, H. (2022). Farklı Branşlarda Spor Eğitimi Alan 10-14 Yaş Arası Bireylerde Statik Dengenin Farklı Değişkenler Işığında İncelenmesi. *Uluslararası İnsan Çalışmaları Dergisi*, 5(10), 385-393. <https://doi.org/10.35235/uicd.1146328>
  38. Wolter, L. L., & Studenski, S. A. (1996). A clinical synthesis of falls intervention trials. *Topics in Geriatric Rehabilitation*, 11(3), 9-19.
  39. Yen, S. & Fu, L. (2008). Dynamic Balance Assessed by Force Plate and Star Excursion Balance Test in Taekwondo Athletes with Ankle Instability. *Medicine & Science in Sports & Exercise*, 40 (5), S441-S442. <https://doi.org/10.1249/01.mss.0000322878.95056.41>.
  40. Yeole, U., & Shah, R. (2020). Effect of Dynamic Postural Control Activities on Balance in Amateur Indian Taekwondo Players. *Indian Journal of Public Health Research & Development*, 11(6), 1036-1041. <https://doi.org/10.37506/ijphrd.v11i6.9932>