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Denge Yetisi ve Sportif Performans İlişkisi

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Öz

Denge, sporcuların koordinasyon, stabilite ve kontrol yeteneklerini içeren kritik bir beceri olarak kabul edilmektedir. Tüm spor branşlarında denge performansı önemlidir. Denge, insanlarda postür ve karmaşık nöromüsküler sistem tarafından yoğun bir düzene göre hareket eder. Bu düzen sayesinde hem dinlenme hem de aktivite sırasında yer çekimi ile ilgili değişikliklere hızlı bir şekilde fiziksel uyum sağlar. Bu uyuma ise 'denge' adı verilir.Bu araştırmanın amacı, çeşitli parametreler ve karmaşık denge sisteminin sportif performans üzerine olan etkisine ilişkin literatürü incelemektir. Araştırma kapsamında 2018-2023 yılları arasında literatür PubMed, Google Scholar, Scopus, YökTez veri tabanları üzerinden taranarak denge yetisi ve performans ilişkisi incelenmiştir. Ulusal veri tabanları için belirlenen beş anahtar kelime: 'denge, statik denge, dinamik denge, performans'. Uluslararası veri tabanları için belirlenen beş anahtar kelime: 'balance, static balance, dynamic balance, performance'.Bulgular, ‘görsel, somatosensör ve vestibüler’ sistemlerin karmaşık etkileşimi ile gerçekleşen denge sistemi, spor branşı, yaş, cinsiyet, yaşam biçimi ve fizyolojik anomaliler gibi çok sayıda parametre tarafından şekillendiğini göstermektedir. Farklı antrenman yöntemleri, egzersizler ve rehabilitasyon stratejilerinin denge performansını artırma potansiyeline sahip olduğu gözlemlenmektedir. Bosu denge egzersizleri, pliometrik antrenmanlar ve core antrenmanları gibi spesifik egzersizlerin, denge performansını olumlu yönde etkileyebildiği gözlenmiştir. Yaşlanma, bilişsel hastalıklar, psikolojik etkenler, ilaç kullanımı gibi faktörlerin de denge üzerinde belirleyici rol oynayabileceği gözlemlenmektedir. Özel gruplardaki bireyler için, işitme engelliler, otizmli çocuklar, multiple skleroz (MS) hastaları ve serebral palsi olan çocuklar için özelleştirilmiş denge ve koordinasyon antrenmanlarının etkili olduğu gözlemlenmiştir. Sonuç olarak, sporcuların bireysel gereksinimleri ve hedefleri doğrultusunda tasarlanan özelleştirilmiş denge egzersizleri ve antrenmanlarının, sportif performans ve denge yetisi üzerinde önemli bir etki potansiyeli taşımaktadır.

The Relationship Between Balance Ability and Sports Performance

Abstract

Balance is considered a critical skill encompassing the coordination, stability, and control abilities of athletes, playing a crucial role across all sports disciplines. The human balance system operates through a sophisticated neuromuscular system and posture, swiftly adapting to gravitational changes during both rest and activity. This adaptation, referred to as 'balance,' is a result of intricate interactions within the visual, somatosensory, and vestibular systems.The aim of this research is to examine the literature regarding the influence of diverse parameters and the complex balance system on athletic performance. A comprehensive review was conducted between 2018 and 2023, utilizing databases such as PubMed, Google Scholar, Scopus, and YökTez. Five keywords were identified for national databases: 'balance, static balance, dynamic balance, performance,' and for international databases: 'balance, static balance, dynamic balance, performance.'The findings reveal that the balance system, shaped by numerous parameters such as sports discipline, age, gender, lifestyle, and physiological anomalies, operates through the intricate interaction of visual, somatosensory, and vestibular systems. Various training methods, exercises, and rehabilitation strategies have shown the potential to enhance balance performance. Specific exercises, including Bosu balance exercises, plyometric training, and core exercises, were observed to positively impact balance performance. Factors such as aging, cognitive diseases, psychological influences, and medication usage were identified as determinants affecting balance.Customized balance and coordination training were found to be effective for specific groups, including individuals with hearing impairments, autistic children, multiple sclerosis (MS) patients, and children with cerebral palsy. In conclusion, personalized balance exercises and training designed according to athletes' individual needs and goals hold significant potential for influencing both athletic performance and balance ability.

Keywords: Balance, performance, static balance, dynamic balance.

Introduction

Sports require not only physical strength but also balance skills. All sports involve a certain level of balance (Eler, 1996). Balance is considered a fundamental element of sports performance and is a crucial factor influencing success in various sports disciplines. An athlete's balance skill can be defined as the ability to maintain body control. Balance holds significant importance in executing rapid and sharp movements, maintaining stability, reducing the risk of injury, and effectively applying technical skills in a sport (Uluç, 2023, p. 119). Evidence suggests that balance performance is task-specific and is expressed in the literature not as a talent but as a skill (Akhilesh et al., 2021).

For efficient and continuous execution of movements during competition or training, maintaining body position is vital. Positional stability depends on the adequacy of balance ability. Balance is a system that allows us to adapt in an environment with cues of balance, including depth perception, and adjust our posture in a way that prevents falling. Information transfer about adaptation in space occurs through deep eyes, eye muscles, and the vestibular system. Once the nervous system receives these inputs, it ensures the extension or flexion of the relevant muscle groups (Baysal, Gündüz, Bayazıt, 2006). This highlights the importance of athletes effectively utilizing visual and vestibular information to optimize their balance skills.

Balance in sports requires the complex coordination of various internal and external inputs. Generally, balance is controlled by sensory inputs, central processes, neuromuscular responses, and vestibular, visual, and proprioceptive systems (Aydog, 2006). The body is almost in postural balance during upright standing. However, external and internal perturbations require postural adjustments to prevent stability loss. This process involves integrating sensory inputs to accurately perceive postural orientation and executing appropriate motor commands to restore postural balance. Balance regulation is not entirely reflex (spinal) guided; instead, higher complex centers such as the motor cortex, basal ganglia, cerebellum, vestibular cortex, and brainstem are involved (Jonh et al., 2018). While balance seems to be a holistic brain phenomenon, certain structures are believed to play significant roles and affect balance disorders. Some of these structures (e.g., cerebellum, basal ganglia, and thalamus) are well-known for their roles in balance, while others (e.g., hippocampus and inferior parietal cortex) might offer alternative explanations as they are not directly associated with balance. Understanding the roles of all regions related to balance throughout life and in different clinical populations is crucial for future research (Alamgir et al., 2012). Higher balance control requires the processing of attention and central information. Therefore, multiple subcortical network mechanisms are strongly linked to cognitive processes (Suna, 2010).

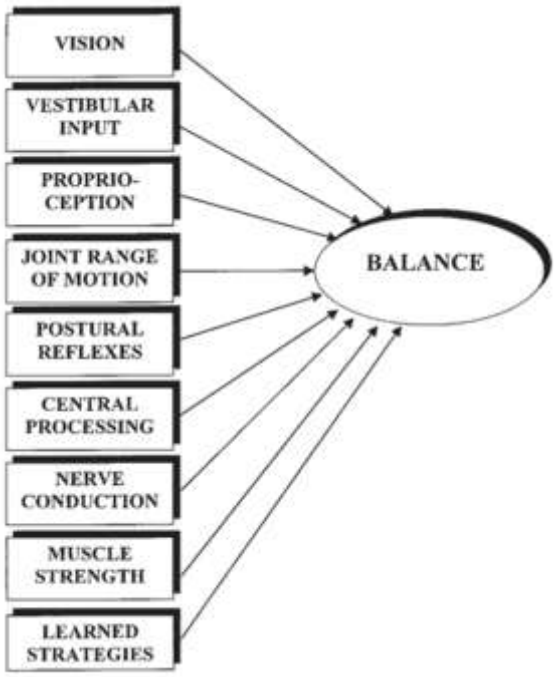

Figure 1. Model of components of balance control. (Yim-Chiplis and Talbot, 2000)

When assessing athletes' performance, diagnosing balance ability holds significant importance for enhancing sporting achievements and safeguarding athlete health. There are two main methods for diagnosing balance performance: measuring the Center of Pressure (COP) displacement and conducting the Sensory Organization Test (SOT) (Suna, 2010). Evaluating postural sway has various potential applications in sports medicine, such as classifying talented athletes, biomechanical examinations, preventing and monitoring sports injuries (Nurtekin et al., 2007). Tests utilizing force platforms and computerized dynamic posturography are the most common and advanced laboratory measurements used to assess various aspects of postural control. By measuring changes in the Center of Pressure (CoP) signal provided by a force platform, the standing posture of the extremities is tested, and postural control is evaluated (Ergen et al., 2007).

It is well-established that impairments in balance performance pose a risk factor for injuries. Studies have associated weakness in balance performance, in both male and female athletes, with an increased risk of lower extremity injuries, particularly ankle injuries (Bahar et al., 2017). Proper diagnosis of balance performance provides a foundation to identify athletes' weaknesses and implement improvements in these areas when necessary. Moreover, a deficiency or imbalance in balance ability can elevate the risk of injury and adversely affect athlete performance (Han et al., 2015; Letafatkar & Alamooti, 2019).

This research underscores the substantial potential of customized balance exercises tailored to meet individual athletes' needs in terms of sport-specific performance and balance ability.

Balance Ability

Balance can be divided into two categories: static balance, defined as the ability to maintain the center of mass over the base of support with minimal movement (Hrysomallis, 2011), and dynamic balance, which refers to the skill needed to balance and stabilize the body during movement. This is considered a fundamental determinant of performance, especially in sports,

and is crucial in reducing the risk of falls in older individuals (Hrysomallis, 2011). Dynamic balance requirements can vary across different sports and age groups. For instance, sports like team games, which require frequent rapid direction changes and sudden stops, necessitate high levels of dynamic balance. In contrast, older individuals may experience challenges in dynamic balance due to aging-related factors (Pau and Leban, 2018).

The concept of composite balance refers to the ability to use both static and dynamic balance while coordinating movements. This form of balance is particularly vital during sports and physical activities, requiring individuals to maintain a stationary position while adapting to rapidly changing conditions (Davlin, 2011). Composite balance involves coordinating the visual, inner ear, and somatosensory systems. The visual system defines environmental references, the inner ear detects head and body movements, and the somatosensory system monitors body position and movement (Horak, 2006). The interaction between these three systems enables individuals to effectively control their movements and maintain instantaneous coordination.

Studies indicate that a sedentary lifestyle can have adverse effects on balance ability. Low physical activity levels can disrupt postural control and increase the risk of falls (Granacher et al., 2013; Shigematsu et al., 2008). Conversely, athletes generally exhibit higher balance abilities (Linthorne, 2001). It's worth noting that athletes' balance abilities can vary depending on the type of sport they engage in; for example, soccer players may have different balance abilities compared to basketball players. Research has shown that soccer players may have lower balance abilities than athletes in other sports (Wong et al., 2010), indicating that athletes' balance abilities can differ based on their training requirements.

In children, balance performance is a crucial skill acquired during the early stages of physical development, forming the foundation for lifelong healthy mobility. These acquired balance skills contribute to improving motor functions, achieving success in sports and play activities, reducing the risk of injury, and enhancing the effectiveness of daily activities (Ruddock, Purvis, Taylor, & Ross, 2017). The development of balance skills in children can vary with age; for instance, as infants gain head and neck control, they gradually develop sitting, crawling, and standing skills. In later years, as they progress to more complex motor skills such as walking, running, and jumping, their balance abilities increase (Clark & Metcalf, 2002). Good balance skills can enhance success in sports activities, reduce the risk of injury, boost children's confidence, and promote independence and active lifestyles (Piek et al., 2008). Therefore, balance performance in children constitutes a cornerstone of motor development.

In adolescents, balance performance is closely related to the growth and development processes. The puberty period leads to physical changes such as alterations in body composition and height. These changes can affect factors like muscle strength and mass, consequently influencing balance performance (Granacher et al., 2013). Additionally, hormonal changes and proportional alterations in the body during adolescence can impact balance abilities. Rapid growth and changes in body composition during this period can make balance control more challenging (Ruddock et al., 2017). The literature suggests that the adolescent period is characterized by rapid and developmental changes in balance performance. Assessing the balance skills of individuals during this phase and supporting them with appropriate exercise programs are crucial for enhancing sports performance.

In adults, balance performance is generally shaped by the demands of daily work, social requirements, and activities such as house chores and sports. Meeting the needs of daily activities and tasks, in addition to sports and other activities, can influence adults' balance abilities (Shumway-Cook et al., 1997). In older individuals, balance performance becomes even more critical. Aging is characterized by physiological changes such as decreased muscle mass, reduced bone density, and sensory impairments like vision and hearing loss. These factors can lead to balance issues and an increased risk of falls (Berg et al., 1989; Tinetti, 1986).

Considering the literature, it's evident that balance performance differs according to age. While balance performance in adults is generally shaped by daily activities, in older individuals, it becomes particularly critical due to physiological changes associated with aging. Therefore, the balance abilities of athletes in each age group should be carefully evaluated, considering factors such as the athlete's age, developmental stages, and the specific requirements of the chosen sport. This study aims to examine the effects of different parameters and the complex balance system on athletic performance based on the existing literature.

Material and Method

Within the framework of this study's methodology, research conducted between 2018 and 2023 has been included to investigate the relationship between balance ability and performance. The search was conducted using the 'PubMed, Google Scholar, Scopus, YökTez' databases. To broaden the scope of the study and incorporate various perspectives, a total of five different keywords were identified for national and international databases. The keywords used for national databases are: 'denge, statik denge, dinamik denge, performans'. For international databases, the following keywords were preferred: 'balance, static balance, dynamic balance, performance'.

Findings

Table 1. Studies Investigating the Effect of Various Parameters on Balance Ability and Their Results

Study	Participants	Material and Method	Findings	Result

"A Study on the Impact of Bosu Balance and Strength Exercise Program on Body Composition, Anaerobic Power, and Balance Ability in Adolescent Female Volleyball Players (Okludil, K., & Serin, E., 2022)."	Experimental Group: 15 participants (mean age 14.87 ± 0.92) Control Group: 15 participants (mean age 14.93 ± 0.70)	The experimental group underwent an 8-week Bosu Balance and Strength Exercise Program, with sessions occurring 3 days per week. Flamingo balance, vertical jump, and standing long jump tests were administered to both the experimental and control groups.	In the experimental group, moderate improvement was observed in flamingo balance, standing long jump, vertical jump, and anaerobic power. However, height, body weight, and body mass index did not show a significant increase after the 8-week program ($p>0.05$). No significant changes were observed in the control group.	The Bosu exercise program has had an impact on balance and strength development in volleyball players.
"Comparison of Y Balance Test Performance Between Women Engaging in Regular Pilates Exercise and Sedentary Women (Ateş, B., et al., 2019)."	Pilates Group (PG): 28 women Control Group (CG): 34 women	Using the Y Balance Test (YBT) platform, reach distances were measured in three directions: Anterior (ANT), Posteromedial (PM), and Posteriolateral (PL). The obtained scores were normalized, and Composite (COMP) scores were calculated. Reach values for the right and left legs were compared.	The Pilates Group (PG) exhibited higher Y Balance Test (YBT) scores in three directions compared to the Control Group (CG) ($p<0.005$). PG generally demonstrated higher performance in COMP scores compared to CG, but this difference was only significant in the right leg reach values. The average differences in right and left leg reach values, particularly in the PM direction with a high value of 5.2 ± 4.9, were greater in CG compared to PG.	It has been determined that regular Pilates exercises have positive effects on dynamic postural control in women.

"Examination of the Effects of Core Stabilization Strength on Balance in Athletes and Sedentary Individuals (Günaydın, E. E., 2020)."	100 participants; (25 sedentary females, 25 female athletes, 25 sedentary males, 25 male athletes).	Core Stabilization and Strength Test, Flamingo Balance Test, and Y Balance Test were administered.	Sedentary females generally showed lower performance in the core stability test. Based on successful and unsuccessful core values, significant differences were found among participants in static balance, Y Balance Test in the anterior plane, and flexibility ($p<0.05$). Moreover, a significant difference was observed in the posteriolateral-posteriomedial planes of the Y Balance Test ($p<0.01$).	The conclusion has been drawn that core stabilization has a significant impact on sports performance and, consequently, on balance ability.
"The Effects of Plyometric Jump Training on Balance Performance in Healthy Participants: A Systematic Review with Meta-Analysis (Ramachandran, A. K., Singh, U., Ramirez-Campillo, R., Clemente, F. M., Afonso, J., & Granacher, U., 2021)."	1,806 participants; (990 males, 816 females).	Systematic literature searches were conducted from electronic databases including PubMed, Web of Science, and SCOPUS. The PICOS approach was employed to define our inclusion criteria.	Plyometric Jump Training has demonstrated similar balance improvements compared to other active control groups (e.g., balance training, resistance training) ($p = 0.534$). Specifically, when Plyometric Jump Training was compared with balance training, both types of training exhibited similar effects on overall (dynamic and static) balance ($p = 0.514$).	The meta-analysis has revealed that Plyometric Jump Training has significant small effects on both dynamic and static balance ($p < 0.001$).

"The Impact of Circular Training Program on Balance and Motor Characteristics in 16-17 Age Group Students (Eskiyecek, C. G., 2019)."	28 Male students; experimental group (n: 14; age: 16 ± 0 years), control group (n: 14; age: 16.79 ± 0.43 years).	In the study, flamingo balance, sit-and-reach flexibility, vertical jump, and back strength tests were applied as pre-tests and post-tests. The students participating in the training underwent static and dynamic balance circular training sessions, two days a week, for one hour each, totaling 8 weeks.	The experimental group showed significant differences in flexibility, vertical jump, back strength, and flamingo balance test values for both right and left sides between pre-tests and post-tests ($p<0.05$). In the control group, significant differences were found in body weight, flexibility, back strength, and BMI values between pre-tests and post-tests ($p<0.05$). In inter-group comparisons, statistically significant differences were observed in the flamingo balance test for the right foot in the post-test ($p<0.05$).	It is believed that the circular training program, focused on balance, is suitable for the developmental level of children and, by emphasizing engagement, contributes to better development.
"Comparison of the Effects of Stabilization Exercises on Core Muscle Function and Balance in Individuals with Traditional Archery Training: A Pilot Study (Kulunkoglu, B., Baş, S. S., Kalkan Balak, B., & Sayan, M., 2022)."	15 Voluntary participants; experimental group (n=9), control group (n=6).	The exercise group received archery training once a week and core exercises twice a week for 7 weeks, while the control group received archery training once a week. Static balance was measured with a single-leg standing test. Static endurance of core muscles was assessed using the McGill protocol, sit-ups, and modified push-ups tests. The strength and endurance of the transversus abdominis and multifidus muscles (TrA+Mul) were evaluated with a pressure biofeedback device. Assessments were conducted twice, before the training and after 7 weeks.	In the exercise group, significant increases were observed in both right and left side plank endurance and TrA+Mul strength within the group ($p<0.05$). In the control group, significant increases were found in left side plank endurance and left balance parameter within the group ($p<0.05$). However, no statistically significant differences were found in other parameters examined in both groups ($p>0.05$).	The study has demonstrated that core stabilization exercises, in addition to traditional archery training, did not create a statistically significant difference in core muscle functions and static balance compared to archery training alone.

"Examination of Static Balance, Lower-Upper Extremity Dynamic Balance, and Reaction Times in Athletes from Different Branches (Türkeri, C., Öztürk, B., Büyüktaş, B., & Öztürk, D., 2019)."	71 Athletes (46 females, 25 males), with an average age of 13.11±1.32 years, participated in the study.	The athletes' static balance, lower-upper extremity dynamic balance, and reaction times were measured according to their sports disciplines (judo, karate, basketball, handball).	There is no significant difference in static balance and reaction time among sports disciplines. However, significant differences were found in favor of judokas in lower extremity dynamic balance scores (p=0.003) and in favor of basketball players in upper extremity dynamic balance scores (p=0.006). No significant relationship was found between reaction time and static balance values or between reaction time and lower extremity dynamic balance scores. A low correlation was determined between upper extremity dynamic balance scores and reaction time (r=−0.232, p=0.05).	Differences have been identified in terms of upper extremity dynamic balance and reaction speed between individual combat sports performed barefoot and team sports involving the use of shoes and a ball.
"Core Exercises in Sports (Egesoy et al., 2018)"	Core exercise studies published between 1999-2016.	Qualitative research methods, document analysis, and content analysis were conducted.	While core training has scientific support, particularly in rehabilitation applications, its applications for performance are limited. These exercises are commonly used in conjunction with training programs that enhance fundamental motor skills. They encompass exercises targeting neuromuscular control, specific contraction types, balance, proprioception, plyometric exercises, and sport-specific skill exercises.	It is believed that incorporating core training into sports and exercise programs is beneficial.

"Effect of Kinesio Taping on Balance Tests in Adolescent Male Basketball and Soccer Players (Yıldız, 2023)."	The study was conducted with a total of 80 amateur athletes (aged 13-16) from 2 football and 1 basketball sports academy.	In the study, athletes had Kinesio taping applied to their right and left knees sequentially. This application was performed with a 65-75% stretch using the mechanical correction technique. Balance tests included the Y Balance Test and Flamingo Test.	The K-taped average results of the basketball group were statistically significantly higher than the soccer group. However, there were no significant differences between the groups in all other measurements. K-tape measurements were found to be higher than the Y Balance test in all measurements. There was no significant relationship between the Flamingo Balance test and sports type and age, but there was a positive relationship between height and leg length ($r=0.238$; $p<0.05$). A significant relationship was found between the K-taped Flamingo test and the non-K-taped test, but no significant relationship was found between the Flamingo Balance test and other measurements.	A positive effect of Kinesio tape on balance was determined ($p<0.05$).

"The Effects of Balance Training on Balance Performance in Adolescents and the Dose-Response Relationship: A Systematic Review and Meta-Analysis (Gebel, A., Lesinski, M., Behm, DG et al., 2018)."	A total of 17 studies were included.	The literature review was conducted on the PubMed and Web of Science databases, covering the period from January 1986 to June 2017. Articles assessed using the PEDro scale focused on balance criteria in healthy youth with an average age of 6-19, including controlled trials.	Balance training in adolescents has shown moderate to large effects depending on age, gender, training status, sports discipline, and training method. Subgroup analyses indicated that these factors did not have a significant impact on overall balance. Balance training in adolescents has moderate to large effects on both static (SMDwm = 0.61) and dynamic (SMDwm = 0.86) balance criteria. There was no significant relationship found between the training period, frequency, total number of training sessions, duration of training sessions, and total training time per week, predicting the effects of balance training on overall balance performance. The largest effects were identified in a 12-week training period (SMDwm = 1.40), training frequency of two sessions per week (SMDwm = 1.29), total training sessions of 24-36 (SMDwm = 1.58), training duration of 4-15 minutes (SMDwm = 1.03), and total training time per week of 31-60 minutes (SMDwm = 1.33).	Balance training is an effective method that can significantly improve overall balance performance in adolescents. This effect may vary depending on the age, gender, training status, environment, and testing method of adolescents.
"Improved Balance with Somatosensory Exercises: A Perspective from Parkinson's Disease (Claesson, I., 2018)."	A total of 28 individuals diagnosed with early Parkinson's disease (PD) participated in the study.	Individuals with early PD (n=28) were tested before and after the intervention (using the BDL balance scale), evaluated with clinical and laboratory results, and compared with a healthy control group.	The BDL Balance Scale has been found to be valid for use in individuals with early Parkinson's disease (PD). Interviews have shown that group dynamics increased motivation and contributed to the formation of new friendships.	As a result, it has been determined that this training method is an effective approach in improving balance in individuals with early Parkinson's disease.

The results of these studies demonstrate that various exercise methods can be effective in enhancing athletes' balance abilities. Specifically, it has been determined that 8 weeks of Bosu balance exercises can improve balance and strength in volleyball players. Furthermore, regular Pilates exercises have a positive impact on dynamic postural control. The importance of core stabilization in affecting sports performance and balance abilities has also been emphasized. It has been concluded that core stabilization exercises are effective in enhancing athletes' fundamental balance skills and contribute positively to sports performance.

Additionally, it has been noted that Plyometric Jump Training (PJT) has positive effects on balance improvement, and these improvements are observed independently of gender and age. The results of these studies indicate that athletes and coaches can consider different training methods to enhance balance. It is crucial to take into account the specific requirements of the sport when aiming to maximize athletic performance. According to the literature review conducted by Egesoy and colleagues, there is a wealth of scientific evidence related to the rehabilitative applications of balance performance in the context of health. However, there is a relative scarcity of studies focusing on performance-related training applications. There is a need for further research on balance ability within the context of sports performance.

Discussion and Conclusion

A study conducted by İrem et al. (2018) explores the impact of Cognitive Exercise Therapy Approach (CETA) on fatigue and balance in individuals with Multiple Sclerosis (MS). Fatigue and balance issues are significant challenges in MS patients, and exercise approaches are recommended to address these parameters. Additionally, musculoskeletal problems can influence posture and balance, particularly through factors like muscle weakness and coordination deficits (Smith & Brown, 2016).

Psychological issues such as depression and anxiety can negatively affect balance. Research indicates that these psychological problems may have an adverse impact on balance performance (Järvekülg et al., 2019). Furthermore, medications can disrupt balance control by affecting the central nervous system (Green et al., 2017).

The study by Karakoç (2019) investigated the effects of eight weeks of balance and coordination training on hearing-impaired judo athletes. The results demonstrated that regular balance and coordination exercises improved the performance of hearing-impaired judo athletes, with dynamic balance exercises showing greater effectiveness compared to static balance exercises.

Motor abnormalities, including poor timing and balance coordination, are observed in children with autism spectrum disorder. The complex interaction involving balance control, information processing, motor planning, and timing of muscle movements makes the study of balance in autism intriguing (Jonh et al., 2018).

In a study focusing on individuals with cerebral palsy (SP), virtual reality (VR) games were found to positively impact balance performance in SP children. This suggests a potential role for VR games in enhancing balance skills in children with SP (Jinlong et al., 2019).

Aging is associated with physical inactivity, sarcopenia, and functional impairments, leading to increased risk of falls. Falls, in turn, are closely linked to balance disorders, especially in older adults (Alamgir et al., 2012). Alzheimer's disease, affecting cognitive functions, can

also lead to balance problems, with fatigue contributing to muscle weakness and attention deficits, further affecting balance (Kayalar et al., 2020; Fatigue Study Group, 2021).

A study by Arzu et al. (2019) compared visual function, balance, and fall behaviors between elderly individuals with normal vision and those with visual impairments. The results indicated lower life quality and functional reach test scores in the visually impaired group.

Regular home exercise programs have been shown to improve balance in elderly individuals at risk of falls (Elsawy & Higgins, 2010). Dizziness prevention exercise programs highlight the importance of balance training, crucial for maintaining postural balance and preventing falls (Yakhoub, 2023).

The interplay of factors affecting balance performance extends beyond the aging process, encompassing psychiatric disorders and various dysfunctions. However, there is limited knowledge about the neural basis of balance and the effects of balance interventions on the brain (Surgent et al., 2019).

Studies on individuals with diabetes reveal a link between neuropathy and balance issues (Morrison et al., 2010; Ghanavati et al., 2012). Diabetic neuropathy leads to both muscle weakness and balance deficiencies (Ali, 2022).

Inner ear problems can stem from vestibular system issues, impacting balance control (Jones et al., 2018). Vertigo, associated with inner ear problems, can cause sudden dizziness and loss of balance (Lee & Kim, 2017).

Traumas and surgeries can result in physical impairments and muscle weakness, leading to balance problems (Wilson et al., 2015).

Neuroplasticity, the nervous system's ability to restructure in response to internal or external stimuli, has been explored in relation to exercise. Studies suggest that endurance athletes may experience motor learning-related neuroplasticity in brain regions associated with motor control (Osman et al., 2019).

In conclusion, the balance system involves active participation from visual, somatosensory, and vestibular receptors. Various training methods and rehabilitation approaches have been explored to improve balance performance. Understanding the impact of age, gender, sports discipline, lifestyle, and physiological anomalies on balance is crucial for evaluating an individual's balance ability and performance. Future research should continue to explore the parameters affecting balance performance and its implications in health, sports, and rehabilitation.

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