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The Effects of Proprioceptive Exercises on Vertical Jump and Balance Performance in Individuals with Different Somatotype Characteristics Engaged in Regular Fitness Training

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Abstract

This study aimed to investigate the effects of proprioceptive exercises on vertical jump and balance performance in individuals with different somatotype characteristics. A total of 67 male volunteers were included in the study and classified into endomorph (n=22), mesomorph (n=22), and ectomorph (n=23) groups. Participants engaged in an six-week proprioceptive exercise program performed twice weekly. The exercise protocol included movements selected for stable and unstable surfaces. Vertical jump performance was assessed using the Smart Jump Mat, while postural stability and balance skills were evaluated with the Sigma Balance Platform under botheyes-open and eyes-closed conditions. Balance performance was analyzedbased on parameters such as center of pressure (COP) swayarea and balance speed. To examine the effects of somatotype (between-subjectfactor: endomorph, mesomorph, ectomorph) and time (within-subjectfactor: pre-test and post-test) on vertical jump and balance parameters, a 3×2 mixed (Mixed ANOVA) design was applied. Prior to the analysis, normality and homogeneity of variances a ssumptions were assessed using the Shapiro-Wilk and Levene tests, respectively. The significance level was set at $p < 0.05$. A significant time effect was observed only for vertical jump performance ($p<0.001$). In the between-group comparisons, a significant difference was found solely in balance speed ($p=0.016$), favoring mesomorph individuals over ectomorphs. While no significant differences were detected in other balance parameters, a moderate improvement trend was observed in the mesomorph group. Proprioceptive exercises may effectively support explosive power development in the short term. However, their impact on balance performance appears to vary depending on somatotype characteristics. Mesomorph individuals demonstrated a more favorable response to proprioceptive stimuli, where as improvements were limited in ectomorph individuals.

Keywords: Proprioceptive Exercise; Balance; Vertical Jump; Somatotype; Postural Stability

Özet

Düzenli Fitness Egzersizleri Yapan Farklı Somatotip Özelliklere Sahip Bireylere Uygulanan Proprioseptif Egzersizlerin Dikey Sıçrama ve Denge Performanslarına Etkisi

Bu çalışmanın amacı, proprioseptif egzersizlerin farklı somatotipe sahip bireylerde dikey sıçrama ve denge performansı üzerindeki etkilerini incelemektir. Araştırmaya, endomorf (n=22), mezomorf (n=22) ve ektomorf (n=23) olmak üzere toplam 67 gönüllü erkek katılımcı dâhil edilmiştir. Katılımcılar, altı hafta boyunca haftada iki gün uygulanan proprioseptif egzersiz programına katılmıştır. Egzersiz programının içeriği stabil ve stabil olmayan Zemin üzerinde uygun olan hareketlerden seçilmiştir. Dikey sıçrama performansı Smart Jump Mat ile değerlendirilirken; postüralstabilite ve denge becerileri, Sigma Balance Platform kullanılarak, gözler açık ve kapalı koşullarda uygulanmış ve COP (Center of Pressure) salınımalanı ile denge hızı gibi parametrelerle analiz edilmiştir. Verilerin analizinde Somatotip (gruplararasıf aktör: endomorf, mezomorf, ektomorf) ve zaman (grup içi faktör: ön test ve son test) değişkenlerinin dikey sıçrama ve denge parametreleri üzerindeki etkilerini incelemek amacıyla 3×2 karma (Mixed) ANOVA analizi uygulanmıştır. Analiz öncesinde normallik varsayımı Shapiro-Wilk testi ve varyans homojenliği Levene testi ile control edilmiştir. Anlamlılık düzeyi $p < 0.05$ olarak kabul edilmiştir. Zaman etkisi açısından yalnızca dikey sıçrama performansında anlamlı bir gelişim tespit edilmiştir ($p<0.001$). Gruplararası karşılaştırmada ise yalnızca denge hızı parametresinde anlamlı farklılık bulunmuştur ($p=0.016$); bu fark mezomorf bireylerin ektomorflara göre daha iyi performans göstermesinden kaynaklanmıştır. Diğer denge parametrelerinde istatistiksel anlamlılık gözlenmemekle birlikte, mezomorf grupta orta düzeyde gelişim eğilimi saptanmıştır. Proprioseptif egzersizler kısa vadede patlayıcı kuvvet gelişimini desteklemekte etkili olabilir. Denge performansı üzerindeki etkiler ise somatotip özelliklerine bağlı olarak farklılık göstermektedir. Mezomorf bireylerin proprioseptif uyaranlara daha olumlu yanıt verdiği, ektomorf bireylerde ise gelişimin sınırlı kaldığı gözlemlenmiştir.

Anahtar Kelimeler: Proprioseptif Egzersiz; Denge; Dikey Sıçrama; Somatotip; Postüral Stabilite

INTRODUCTION

Studies conducted at the general population level have revealed that regular exercise has positive effects on physical fitness. These effects include critical health-related gains such as improved capacity for maintaining an active lifestyle, increased aerobic endurance, and enhanced muscular strength (1). Among individuals who are not athletes but engage in regular physical activity, the content of the exercise programs plays a determining role in their motor performance gains. In this context, proprioceptive exercises aimed at improving balance, coordination, and muscle control can lead to significant improvements not only in athletes but also in regularly exercising individuals (2).

Proprioceptive exercises, as one such program, enhance balance and motor control mechanisms by enabling the central nervous system to perceive feedback related to body position, movement, and muscle tension levels (3). Previous studies have shown that these exercises improve dynamic balance, postural control, and reaction time in both sedentary individuals and those who engage in regular physical activity (2).

Individuals' physical structures can influence their physiological and biomechanical responses to exercise. At this point, somatotype emerges as a significant variable, representing a classification system that reflects an individual's genetic and morphological structure, and which affects both body composition and motor performance. These classifications are defined as ectomorph, mesomorph, and endomorph (4).

Somatotypes are categorized into three main types: endomorph (characterized by dominant adipose tissue), mesomorph (characterized by dominant muscularity), and ectomorph (characterized by a slim, linear build) (5). These structural differences are reported to affect individuals' strength production, balance mechanisms, and proprioceptive responses differently. Furthermore, it has been noted that somatotype characteristics in physically active individuals may lead to significant differences in motor performance-related parameters (6).

Mesomorphic individuals are generally more successful in explosive strength and vertical jump tests, whereas ectomorphic individuals may have an advantage in balance tests due to their lower body mass (5). These distinctions underscore the necessity of individualizing exercise programs and highlight the importance of physiologically-based approaches.

Exercise specialists and athletic trainers are responsible for designing physical exercise programs with the aim of prescribing exercise, promoting regular physical activity, or achieving fitness and performance goals (7). In this context, it has been emphasized that, in order to provide appropriate doses of exercise-induced stress stimuli, exercise specialists and personal trainers should consider individuals' genetic characteristics, developmental status, morphological structure, demographic factors, and environmental conditions, as well as their adaptive responses to these variables (8).

In light of this information, investigating the effects of a six-week proprioceptive exercise program applied according to different somatotype characteristics—on selected motor performance parameters in individuals who engage in regular fitness exercise is considered important. Such investigation may contribute both to enhancing the effectiveness of personalized exercise programs and to better understanding somatotype-based differences in practical applications.

METHOD

Research Design

This study employed a quasi-experimental design with a pre-test–post-test comparison and without a control group. The quasi-experimental research model is a method used to examine the effect of a specific variable and to evaluate the relationship between this variable and the outcomes within a cause-effect framework. In this model, the data obtained are analyzed comparatively to reach measurable results (9). The present study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Study Group

A total of 67 male participants aged between 19 and 26 years who regularly engaged in fitness exercise voluntarily took part in the study. Participants were classified according to their body types using the Heath-Carter anthropometric somatotype method and grouped as follows: Endomorph (n=22), Mesomorph (n=22), and Ectomorph (n=23). All participants underwent a proprioceptive exercise program for six weeks, performed twice a week for approximately 45 minutes per session. The exercises were conducted using balance boards, Swiss balls, BOSU balls, and unstable surfaces in single-leg stances, and were planned with progressively increasing difficulty (Table 1).

Table 1. Six-Week Proprioceptive Training Program

Warm Up	Method	Sets x Reps	Tempo/Time	Rest
Calf stretch, Hamstring stretch, Quadriceps stretch, IT-Band stretch	Dynamic	1 x 10 (R-L)		
Chest stretch,Back stretch (child pose)	Static	1	30 sec	
Balance	**Method**	**Sets x Reps**	**Tempo/Time**	**Rest**
1-3. Weeks				
Single-leg balance reach (Sagittal-frontal plane)	Unilateral	2x12 (R-L)		30 sec
Bosu ball single-leg balance with throw and catch	Unilateral	2 (R-L)	30 sec	30 sec
Wobble board squat	Bilateral	2x12		30 sec
Two hands hold stick on single leg on bosu ball	Unilateral	2 (R-L)	30 sec	30 sec
Elbow to hands plank on bosu ball	Bilateral	2	30 sec	30 sec
4-6. Weeks				
Single-leg balance reach (Touch the target-multiplane)	Unilateral	2 (R-L)	30 sec	30 sec
(Pair) Bosu ball single-leg balance (Touch the target with hands)	Unilateral	2 (R-L)	30 sec	30 sec
(Pair) Wobble board squat (Touch the target with hands)	Bilateral	2	30 sec	30 sec
(Pair) One hand hold stick, the other touch the target, single-leg	Unilateral	2 (R-L)	30 sec	30 sec
(Pair) Plank on bosu ball (Touch the target)	Bilateral	2	30 sec	30 sec
Cool Down	**Method**	**Sets x Reps**	**Tempo/Time**	**Rest**
Calf stretch, Hamstring stretch, Quadriceps stretch, IT-Band stretch, Chest stretch, Back stretch (child pose)	Static	1	30 sec	

Data Collection Tools

Height and Body Weight Measurement

Participants' height was measuredusing a Secastadiometer, with participants standing barefoot in an anatomicalposture. Body weight was alsomeasuredusing the same device, with measurements taken in the morningwhile participants were fasting and after they had used the restroom.

Body Mass Index (BMI)

BMI was calculatedbydividing body weight (kg) by the square of height in meters (m^2) (kg/m^2).

Somatotype Classification Method

An anthropometric method developed for somatotype classification was used (10). This method evaluates the endomorph (fatness), mesomorph (muscular and skeletaldevelopment), and ectomorph (linearity) components of individuals. Required body measurements were obtained using a skinfoldcaliper (11).

Body Composition Measurement

Body fatpercentage was estimatedthroughskinfold measurements taken with a skinfoldcaliper. Measurements were obtained from the triceps, subscapular, suprailiac, abdominal, thigh, and calfregions. The collected values were thencalculatedusing a specificformula (12).

Vertical Jump Performance Measurement

Lower limbexplosivepower was assessedusing the Fusion Smart Jump Mat. Participants were asked to perform a maximalvertical jump with their hands on their hips. The devicecalculated jump height based on groundcontact time and flight time (13).

Balance Performance Measurement

Postural stability and balance ability were evaluatedusing the Sigma Balance Platform. Participants stood on the platform and performed tests thatrequiredmaintaining balance with eyesopen and closed. The platform quantitativelyanalyzed balance performance using parameters such as center of pressure (COP) swayarea and velocity (14).

Statistical Analysis

Before analyzing the data obtained in the study, normalitydistribution was assessedusing the Shapiro-Wilk test, and homogeneity of variances was evaluatedusingLevene's test. Since the data met parametricassumptions, a 3×2 Mixed ANOVA was applied to analyze the effects of somatotype and time on vertical jump and balance performance. In cases of significantinteraction, Bonferroni-corrected post-hoc tests were conducted to determine pairwise differences. Partialetasquared (η^2) values were used to interpret effect sizes, and Cohen'*sd*coefficients were used to evaluate within-groupchanges. Percentagechanges in performance parameters before and after the exercise program were calculatedusing the followingformula (15): % Change = [(Post-test – Pre-test) / Pre-test] × 100

Additionally, a power analysis was conducted using the G*Power 3.1 software to determine whether the sample size was statisticallysufficient. In this analysis, a medium effect size (f = 0.25), a significancelevel (α = 0.05), and a statisticalpower of 95% (1 – β = 0.95) were considered. A RepeatedMeasures ANOVA (within–betweeninteraction) was selected in accordance with the study design, which includedthreegroups and two time points.

Ethical Approval and Institutional Permission

This study was approved by the Ethics Committee of Istanbul Gelisim University in accordance with ethical principles, under the session dated 16.08.2024 (Meeting No: 2024-12, Decision No: 2024-12-07).

FINDINGS

Table 2. Descriptive Characteristics of Participants by Somatotype

Group	Variable	N	Min.	Max.	Mean ± SD
Endomorph	Age (year)	22	19	26	21,23 ± 1,82
	Height (m)	22	1,65	2,03	1,79 ± 0,09
	Body Weight (kg)	22	63	107	78,85 ±10,96
	BMI (kg/m²)	22	21,80	28,00	24,52 ± 1,59
Mesomorph	Age (year)	22	20	23	21,32 ± 1,25
	Height (m)	22	1,67	2,05	1,78 ± 0,07
	Body Weight (kg)	22	68	108	79,84 ± 9,54
	BMI (kg/m²)	22	21,30	31,90	25,18 ± 2,46
Ectomorph	Age (year)	23	19	24	21,26 ± 1,45
	Height (m)	23	1,66	1,97	1,78 ± 0,08
	Body Weight (kg)	23	53	95	67,81 ±11,02
	BMI (kg/m²)	23	17,70	31,50	21,31 ± 3,19

When Table 2 is examined, the mean age of participants in the endomorph group was 21.23 ± 1.82 years, with a mean height of 1.79 ± 0.09 meters, body weight of 78.85 ± 10.96 kg, and a BMI of 24.52 ± 1.59 kg/m². In the mesomorph group, the mean age was 21.32 ± 1.25 years, height 1.78 ± 0.07 meters, body weight 79.84 ± 9.54 kg, and BMI 25.18 ± 2.46 kg/m². For the ectomorph group, participants had a mean age of 21.26 ± 1.45 years, height of 1.78 ± 0.08 meters, body weight of 67.81 ± 11.02 kg, and BMI of 21.31 ± 3.19 kg/m².

Tablo 3. Time, Time × Group Interaction, and Between-Group Differences in Pre- and Post-Exercise Measurements

Variables	Time Effect			Time x Group Interaction			Group Effect			Significiant Difference
	F	p	η²	F	p	η²	F	p	η²	-
Vertical Jump	51,301	**,000****	,445	1,885	,160	,56	1,214	,304	,037	-
Balance Deviation	,010	,921	,000	,825	,443	,025	1,297	,281	,039	
Balance Velocity	1,528	,221	,023	1,310	,227	,039	4,450	**,016***	,122	**Mesomorph> Ectomorph**
Balance Path Length	,909	,344	,014	1,861	,164	,055	2,920	,061	,084	-

*p < .05 = *, p < .001 = *; *η² = Partial Eta Squared (Effect Size)*

When Table 3 is examined, the analysis revealed a statistically significant main effect of time only for the vertical jump parameter ($F = 51.301$; $p < .001$; $\eta^2 = .445$), indicating a notable improvement in vertical jump performance from pre- to post-test across all groups.There was no significant Time × Group interaction for any of the variables ($p > .05$), suggesting that the change over time did not differ significantly among the somatotype groups.Regarding the main effect of group, a statistically significant difference was observed only in balance velocity ($F = 4.450$; $p = .016$; $\eta^2 = .122$). Post-hoc comparisons indicated that this difference favored the Mesomorph group over the Ectomorph group($p = .013$). No other significant between-group differences were found in the remaining parameters ($p > .05$).

Table 4. Pre-Test and Post-Test Mean Values, Percentage Changes, and Effect Sizes (Cohen's *d*) by Group

Group	Variables	Pre Test	Post Test	Change (%)	Effect Size (*d*)
Endomorph	Vertical Jump	35,43±3,78	38,10±3,46	%7,53	Medium
	Balance Deviation	,07±,10	,05±,09	-%25,0	Small
	Balance Velocity	,54±,16	,56±,16	%3,70	Small
	Balance Path Length	15,23±4,39	15,36±4,33	%0,85	None
Mesomorph	Vertical Jump	34,78±5,87	39,09±5,77	%12,39	None
	Balance Deviation	,01±,08	,03±,07	%200,0	Small
	Balance Velocity	,57±,17	,67±,22	%17,54	Medium
	Balance Path Length	15,48±4,59	18,28±6,28	%18,06	Medium
Ectomorph	Vertical Jump	37,35±3,53	39,74±4,56	%6,40	Medium
	Balance Deviation	,05±,08	,05±,08	%0,00	None
	Balance Velocity	,51±,19	,50±,13	-%1,96	None
	Balance Path Length	14,61±5,40	13,90±3,61	-%4,86	Small

*p < .05, **p < .001;
E.S. = Effect Size. Effect size levels based on partial eta squared (η²):
η²< 0.01 = None, 0.01 ≤ η² < 0.06 = Small, 0.06 ≤ η² < 0.14 = Medium, η² ≥ 0.14 = Large.

When Table 4 is examineda moderate level of improvement in vertical jump performance across participants. In addition, mesomorphic individuals exhibited moderate effect sizes in both balance velocityandbalance path lengthparameters. However, among the endomorphic and ectomorphic groups, no significant improvement was observed in balance-related parameters.

DISCUSSION AND CONCLUSION

In this study, the effects of an eight-week proprioceptive exercise program on vertical jump and balance performance were examined in individuals with different somatotype characteristics. According to the findings, a statistically significant effect of time was observed only in the vertical jump parameter, while no significant time effect or time × group interaction was found in the balance parameters. On the other hand, between-group comparisons revealed that mesomorphic individuals exhibited significantly superior performance in the balance speed parameter compared to ectomorphic individuals. These findings suggest that proprioceptive exercises may support the development of explosive strength in the short term, whereas their effects on balance may vary depending on individuals' morphological characteristics.

In the literature, proprioceptive training has been reported to enhance rapid for coproduction through early and synchronize deactivation of motor units (16). In this context, our study observed improvements in vertical jump performance across all groups, ranging from 6% to 12%, with a particularly notable increase of 12.39% in the mesomorphic group. Moreover, it has been suggested that mesomorphic individual spossess higher muscle mass and an athletic morphology (17,10), which may enhance their capacity to respond more rapidly to proprioceptive stimuli and confer an advantage in motor control mechanisms (18,19).Similar short-term enhancements in vertical jump performance have been reported following proprioceptive training, with improvements observed in explosive power and agility (20, 30).

A meta-analysis has demonstrated that proprioceptive training significantly contributes to the development of explosive strength, particularly when combined with plyometric exercises (21). Although the program implemented in our study consisted solely of proprioceptive exercises, the significant improvement observed in vertical jump performance ($p < .001$) suggests the possibility of favorable changes in the contraction-relaxation capacity of the muscle-tendon unit. This indicates that proprioceptive exercises may indirectly support explosive force production by enhancing neuromuscular coordination (22,23). A recent study demonstrated that proprioceptive mat training significantly improved countermovement jump performance in volleyball players (24). Similarly, a related study reported that proprioceptive training enhances explosive strength by increasing the rapid and efficient activation of motor units (25). This finding is consistent with the improvement observed in vertical jump performance in our study.

On the other hand, the absence of a statistically significant time effect in the balance parameters may be attributed to factors such as the short duration of the intervention, the difficulty level of the exercises, or the sensitivity of the measurement instruments. Another study has indicated that a minimum intervention period of 12 weeks is necessary to achieve significant improvements in balance performance (26), emphasizing that shorter interventions may yield limited effects (27,28). For instance, an 8-week proprioceptive training program was reported to significantly improve static and dynamic balance in adolescent soccer players, though younger populations may exhibit faster neuromuscular adaptations compared to adults (29). However, unlike adolescent athletes who may demonstrate heightened neuromuscular plasticity, individuals engaged in recreational fitness may require longer or more intensive interventions to achieve similar balance-related adaptations. In this regard, the eight-week duration applied in our study may have been insufficient for eliciting meaningful improvements in balance.

In our study, although moderate effect sizes were observed in the mesomorphic group for both balance speed (17.54%) and balance path (18.06%) variables, these differences did not reach statistical significance. This highlights the importance of distinguishing between statistical significance and practical significance. A systematic review reported that proprioceptive training positively contributes to athletic performance components such as balance, explosive strength, and postural stability (30). These findings support the notion that mesomorphic individuals may respond more favorably to proprioceptive exercises (31,32).Additionally, one study demonstrated that mesomorphic athletes exhibited significantly better dynamic balance control compared to both endomorphic and ectomorphic groups, even though static balance remained similar across somatotypes underscoring the relevance of morphological characteristics in dynamic postural tasks (33). Other studies have also shown that proprioceptive exercises can enhance postural stability (34,35). In this context, it may be suggested that mesomorphic individuals are able to process proprioceptive signals more efficiently. On the other hand, the changes observed in balance parameters within the ectomorphic group were quite limited; in particular, a declining trend was noted in the balance speed and balance path variables. Although proprioceptive training is generally reported to have positive effects on balance and postural control, it is important to note that these effects may vary depending on somatotype (30). Furthermore, other studies have also shown that proprioceptive exercises can enhance postural stability (33,34). In this context, it may be suggested that mesomorphic individuals are able to process propri On the other hand, the changes observed in balance parameters within the ectomorphic group were quite limited; in particular, a declining trend was noted in the balance speed and balance path variables. Although proprioceptive training is generally reported to have positive effects on balance and postural control, it is important to note that these effects may vary depending on somatotype (30).

Structural disadvantages of ectomorphic individuals such as low muscle mass and poor trunk stabilization may limit the benefits gained from proprioceptive training (37,38). Therefore, it can be suggested that proprioceptive performance is influenced not only by the applied exercise protocol but also by the individual's morphological characteristics proceptive signals more efficiently, thereby developing postural control more rapidly.

In the endomorphic group, although a notable 25% reduction was observed in balance deviation, this difference did not reach statistical significance due to the initially low baseline values and the limited sample size (5). Another study has indicated that endomorphic individuals may exhibit lower balance performance compared to other body types due to higher fat mass and lower muscle tone. This relationship is supported by Peterson et al., who found that greater fat mass negatively impacts neuromuscular control and physical performance, while lean body mass is positively associated with strength and balance (39).Similarly, it has been emphasized that postural control may be limited in endomorphic individuals and that such morphological features may act as structural barriers to balance development (34).Furthermore, endomorphic participants demonstrated greater postural sway in dynamic conditions than mesomorphs and ectomorphs, likely a result of the combined effect of higher body mass and reduced muscle torque (30).In this context, the limited improvements observed in endomorphic individuals in our study appear to be consistent with the existing literature.

This study has several limitations. The inclusion of only young male participants limits the generalizability of the findings. The exercise duration, restricted to eight weeks, may have been insufficient, particularly in terms of balance development. Furthermore, applying the same exercise program to all participants may have overlooked individual differences. The absence of neurological measurements such as muscle activation, as well as the lack of control over factors like nutrition and sleep, also represent additional limitations of the study.

CONCLUSION AND RECOMMENDATIONS

This study examined the effects of an eight-week proprioceptive exercise program on vertical jump and balance performance in individuals with different somatotype characteristics. Based on the findings, the implemented exercise program improved vertical jump performance across all groups, with the most pronounced gains observed in mesomorphic individuals. On the other hand, no significant time effect or time × group interaction was found for the balance parameters. However, between-group comparisons revealed that mesomorphic individuals performed better in balance speed compared to ectomorphic individuals. These results suggest that proprioceptive exercises particularly support the development of explosive strength in the short term, while their effects on balance performance may vary depending on an individual's morphological characteristics. The limited benefits observed in ectomorphic individuals with low muscle mass indicate that somatotype is a significant variable in determining responses to exercise.

According to the findings of the present study, proprioceptive exercises may be effective for the development of explosive strength in mesomorphic individuals and can be prioritized in training programs for this group.For ectomorphic and endomorphic individuals, the duration of training should be extended and supported with fundamental strength exercises to enhance balance development. Future studies with longer intervention periods may more clearly reveal the impact of somatotype on balance improvement.Theeffects of proprioceptive exercises should also be evaluated in conjunction with variables such as surface type, loading method, and psychological factors.

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