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RESEARCH

A STUDY WHICH INVESTIGATES THE RELATIONSHIP OF AGE, TRUNK STRENGTH, AND BALANCE PARAMETERS WITH FALL RISK

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ABSTRACT

Introduction: Age-related neural and sensory deteriorations and decline of the musculoskeletal systems affect balance and increase the risk of fall. Our objective in this study is to determine how balance and the risk of fall are affected by increasing age, and search the role of trunk muscle strength on balance.

Materials and Method: A total of 90 female voluntary participants were divided into the age groups of 20–39, 40–59 and ≥60 years (n = 30 for each group). Static balance abilities and the fall risks of the subjects were determined using a computer-aided static posturography device and their trunk muscle strength at 60°/s and 120°/s were assessed using the isokinetic dynamometer equipment.

Results: When the 20–39 age groups are compared with 40–59 and ≥60 age groups regarding the balance measurements, higher index values at low and medium frequency oscillations were detected. Assessment of the correlation between age and Fourier indexes showed that more balance scores were found to deteriorate with increasing age. The deterioration in the balance parameters was observed to be correlated with the trunk flexor and extensor muscle strength, reducing with increasing age.

Conclusion: It was determined that static balance parameters tend to deteriorate and the risk of falls increases with increasing age. The decreasing trunk muscle strength was found to be related to the decline in balance ability and an increased risk of falling.

Kew Words: Aged; Postural Balance; Accidental Falls.

ARAŞTIRMA

YAŞ, GÖVDE KAS KUVVETİ VE DENGE PARAMETRELERİ İLE DÜŞME RİSKİ ARASINDAKİ İLİŞKİYİ İNCELEYEN BİR ARAŞTIRMA

ÖZ

Giriş: Yaşla ilişkili nöral, sensoriyal ve/veya kas iskelet sistemlerindeki bozulmalar dengeyi etkilemekte ve düşme riskini arttırmaktadır. Bu çalışmanın amacı; artan yaşla birlikte dengenin ve düşme riskinin nasıl etkilendiğini saptanması ve gövde fleksör ve ekstansör kas kuvvetinin denge üzerindeki rolünün araştırılmasıdır.

Gereç ve Yöntem: Yaş dağılımı 20-39, 40-59, 60 yaş ve üzerinde olan üç yaş grubundan, her gruptan 30'ar kişi olmak üzere toplam 90 kadın gönüllü çalışmaya alınmıştır. Katılımcıların statik denge yetenekleri ve düşme riskleri bilgisayar destekli statik postürografi cihazı, 60 ve 120 derece/saniyedeki gövde ekstansör ve fleksör kas kuvveti izokinetik dinamometre cihazı kullanılarak değerlendirilmiştir.

Bulgular: Denge ölçümlerinde 20-39 yaş grubu 40-59 ve 60 yaş ve üzeri grupları ile karşılaştırıldığında düşük ve orta salınım frekanslarda yüksek indeks değerleri saptanmıştır. Yaş ve Fourier indeks değerleri arasındaki korelasyonu değerlerlendirildiğinde ilerleyen yaşla birlikte daha fazla denge skorunda bozulma olduğu görülmüştür. Denge parametrelerindeki bu bozulmanın yaşla birlikte azalan gövde fleksör ve ekstansör kas kuvveti ile ilişkili olduğu tespit edilmiştir.

Sonuç: İlerleyen yaşla birlikte statik denge parametrelerinin bozulma eğilimde olduğu ve düşme riskinde artış olduğu saptanmıştır. Azalan gövde kas gücünün azalan denge kabiliyeti ve düşme riskinde artış ile ilişkili olduğu bulunmuştur.

Anahtar Sözcükler: Yaşlı; Postural Denge; Düşme Riski.

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INTRODUCTION

As a part of life, ageing is a progressive process in which physiological changes in several organ systems occur along with an increase in the incidence of acute and chronic diseases. Maintaining trunk balance in old age is essential to perform many physical functions and for the functional independency of the ageing individual. Loss of function in afferent and efferent mechanisms that maintain balance occurs with ageing. In a previous study, it was reported that the balance was deteriorated in 13% of individuals of ages between 65–69 years and in over 46% of individuals of ≥85 years of age (1). Additionally, adequate trunk control is necessary for postural control, to achieve stability (balance) during the posture changings and perform daily life activities and normal mobility. The decreases in muscle mass, strength and durability that occur with ageing also adversely affect the balance. In a study carried out on the old, it was reported that the balance protection capacities of the patients whose ankle dorsiflexion muscle strength was increased via electrostimulation of the ankle dorsiflexor muscles was also increased. (2). It is also known that a balance disorder constitutes a risk factor for falling, especially in older individuals (3). The purpose of this study is to determine the effect of age on static balance parameters and risk of falls, as well as examining the role of trunk flexor and extensor muscle strength in balance.

MATERIALS AND METHOD

A total of 90 female participants who had applied to outpatient rehabilitation clinic, between the age of 20–82 years with an average age and standard deviation (sd) of 49.47±17.61 years were included in this study. The participants were divided into three age groups of 20–39, 40–59 and ≥60 years, with 30 participants in each group. The average ages and SD of each of these age groups were 28.63±3.96, 50.33±5.40 and 69.46±6.57 years, respectively.

Participants who were found fit to perform the balance tests and capable of ambulating independently without the use of any assistive device were included in the study. Those who had neurologic, psychiatric and cognitive disorders, visual impairments, hearing difficulties, or acute diseases that cause balance disorder were excluded from the study. Demographical data (age, height, weight, smoking status, background and family history) of the participants were collected. All subjects provided written informed consents.

This study was approved by Baskent University Institutional Review Board and Ethics Committee (Project no: KA09/385) and supported by Baskent University Research Fund and all subjects provided written informed consent.

Assessment of Balance and Risk of Fall

Static balance abilities and fall risks of the participants were assessed through a computer-aided static posturography device (Tetrax, Sunlight Medical Ltd.). This device is made up of a single platform, four independent sensors that measure the vertical pressure changes from the fingertips and heels of both feet and a computer that processes the digital data derived from the sensors. Tests were carried out by having the participants stand on the platform in eight different postures: normal posture, eyes open (NO); normal posture, eyes closed (NC); on pillow, eyes open (PO); on pillow, eyes closed (PC); head turned right, eyes closed; head turned left, eyes closed; head tilted 30° back, eyes closed and head tilted 30° down, eyes closed. The tests lasted 32 s per posture. Each participant's fall index was calculated by considering the oscillation rates from the posturographic software, general stability index (ST) for each of four postures (i.e. NO, NC, PO and PC) and the measurements made in F1–8 frequencies within a range of 0.01–3 Hz were assessed. The stability index and general stability expressed by static posturography are the indicators of the oscillation on four plates and the steady posture of the participants. The stability index (ST) measured by static posturography is a mathematical and numerical result that expresses the extent of posture oscillation. Static posturography stability index is the numerical expression of the patients' posture disorders, controls and remedies that cannot be observed clinically. Moreover, this index is independent of the weight and height of the individual. A Fourier frequency within the range of 0.01–0.1 Hz is referred to as a low frequency (F1), and it is related to the visual control, normal posture and undisturbed posture. The frequencies within the range of 0.1–0.5 Hz are referred to as a low-medium frequency (F2–4) band and are sensitive to vestibular stress and disorders. The frequencies within the range of 0.5–1 Hz are considered to be in the medium-high frequency (F5–6) band and reflect the somatosensory activity and postural reflexes related to the lower extremities. Frequencies >1 Hz (F7–8) originate from central nervous system dysfunctions (4). The general stability index in the assessed posture fall index and the high scores in the F1–8 Fourier analyses were assessed as higher instability. Fall Index Assessment with static posturography is designed to assess the individual's risk of falling. The static posturography fall index was obtained from the balance measurements of patients and is an indicator of the balance disorders in patients. Individuals with a fall index of 0–36 are classified as having a low risk of falling; 36–56 as a medium risk and 56–100 as a high risk. There have been some articles that have used the fall index as an indicator for the risk of falling in the literature (5).

Assessment of Trunk Muscle Strength

Trunk extensor and flexor muscle strengths of the participants were assessed through the use of Cybex 770 Norm (Lumex Inc., Ronkom Koma, RY, USA) equipment. Measurements were carried out at times when the participants felt fine and were fully motivated. The participants stood with an upright posture with both of their feet touching the foot support of the waist unit, with their back leaning against the scapular support of the equipment. Moreover, their chest was supported by a chest pillow, the abdomen was fastened with a safety belt and the use of special stabilisers was aligned with both the lower extremities of the femur and the knees. The participants' anatomic neutral postures while standing in the upright position were determined. Trunk extension and flexion gaps were entered into the device in degrees. The trunk extension was limited to 15°, whereas flexion was limited to 95°. Measurements were carried out using the isokinetic modes available in the software of the Cybex Norm 700 device. The isokinetic measurements were tested at the rates of 60°/s and 120°/s, with five repetitions for each set and 30 s of rest time between each set. The device and the procedures to be followed were introduced to the participants three to four times in advance. It was also ensured that the participants were motivated and familiarised with the device, and the tests were conducted afterwards. Verbal warnings were made to motivate the participants, and the maximum muscle strength was achieved by encouraging the participants. The peak torque values [Nm] were obtained in consequence of all the measurements, and recorded as the foot/pound (ft/lb), as the default unit of measure used by the device.

STATISTICAL ANALYSIS

Data analyses were conducted on SPSS for Windows 11.5 program. The point whether the distribution of continuous variables was normal was examined with the Shapiro–Wilks' test. Descriptive statistics were set forth as median (interquartile range). The importance of the differences among age groups, in terms of fall index, Fourier index in different postures, general stability measurements and body muscle strength indicators was assessed by means of the Kruskal–Wallis test. In the case that the result of the Kruskal–Wallis test statistic was found important, the multiple comparison test was utilized in order to determine the cases that lead to significant differences. The point whether there was a significant correlation between the continuous variables was examined by the Spearman's correlation test. $p<0.05$ was considered statistically significant.

RESULTS

The increase in the fall index values with increasing age was found to be statistically significant ($p<0.05$). Additionally, there was a statistically significant difference in terms of the fall index values between the age groups of 20–39 and ≥60 years, as well as 40–59 and ≥60 years ($p<0.05$) (Table 1).

Table 1— Fall Index Values by Age Group. Correlation Coefficients and Significance Levels Between Age, Fall Index Values and Trunk Muscle Strength Indicators

Variables			**Fall Index**	
Age			**Median (IR)**	
20–39 years (n = 30)			25.0 (30.0)*	
40–59 years (n = 30)			28.0 (30.5)†	
?60 years (n = 30)			41.0 (39.0)*,†	
P			0.029	
Trunk strength	Age		Fall Index	
	r	p	r	p
Flexion at 60 d/s	-0.479	<0.001	-0.262	0.012
Flexion at 120 d/s	0.009	0.933	0.004	0.969
Extension at 60 d/s	-0.464	<0.001	-0.210	0.047
Extension at 120 d/s	-0.087	0.417	-0.154	0.146

IR, Interquartile range
*Statistically significant difference between the age groups of 20–39 and ?60 years (p = 0.010)
†Statistically significant difference between the age groups of 40–59 and ?60 years (p = 0.012)

Table 2— Examination of the Fourier Indexes for Different Postures and General Stability Values by Age Group

Variables	20–39 years		40–59 years		≥60 years		p
	Median	IR	Median	IR	Median	IR	
F1NO	15.88	13.68	13.10	8.71	13.27	9.87	0.131
F2NO	9.67	7.29	10.55	4.28	9.48	5.33	0.591
F3NO	5.97	3.69	7.46	4.50	6.15	3.09	0.403
F4NO	4.45	2.27	4.86	2.79	4.83	2.04	0.751
F5NO	2.81	1.07	2.97	1.23	2.72	1.66	0.478
F6NO	1.70	1.14	1.84	1.32	1.78	1.29	0.863
F7NO	0.65	0.46	0.67	0.35	0.74	0.39	0.869
F8NO	0.16	0.20	0.18	0.15	0.17	0.15	0.639
F1NC	11.06	5.49	13.53	8.58	12.10	8.88	0.358
F2NC	10.15‡	2.79	13.31‡	7.08	12.71	4.60	0.007
F3NC	7.99	3.75	8.61	5.69	9.11	5.14	0.408
F4NC	6.28	3.50	6.24	3.92	6.67	3.22	0.625
F5NC	3.46	1.86	3.95	2.20	3.92	3.59	0.180
F6NC	2.16	1.13	2.96	2.12	3.33	3.12	0.058
F7NC	0.79	0.49	0.83	0.51	0.98	0.92	0.312
F8NC	0.19	0.14	0.16	0.12	0.15	0.18	0.520
F1PO	18.13	10.77	14.38	8.50	15.71	12.67	0.419
F2PO	8.76	4.64	10.75	6.75	10.52	6.73	0.681
F3PO	5.69§	3.04	6.71	4.20	7.54 §	3.45	0.011
F4PO	4.08	1.93	4.86	1.78	5.09	2.73	0.097
F5PO	3.18	1.09	3.29	1.16	3.45	1.93	0.711
F6PO	2.40	1.67	2.49	0.87	2.11	1.30	0.453
F7PO	0.79	0.38	0.83	0.28	0.87	0.39	0.563
F8PO	0.18	0.11	0.17	0.15	0.18	0.14	0.814
F1PC	15.31	12.01	18.99	12.36	14.44	9.71	0.138
F2PC	13.41	6.16	13.84	9.78	14.92	5.67	0.578
F3PC	10.92	6.31	11.43	6.95	9.24	5.56	0.326
F4PC	6.99	4.04	8.01	4.23	8.27	6.40	0.263
F5PC	5.34	2.23	5.57	2.27	4.90	2.72	0.690
F6PC	3.82	2.48	4.27	2.22	3.34	2.36	0.370
F7PC	1.23	0.76	1.32	0.53	1.30	1.06	0.452
F8PC	0.21	0.25	0.18	0.09	0.19	0.11	0.405
NOST	10.85	4.16	12.08	5.82	11.29	5.52	0.557
NCST	15.94§	6.25	16.98	8.40	21.15 §	12.48	0.037
POST	14.14	5.53	14.46	4.63	13.72	6.67	0.792
PCST	22.35	10.24	25.95	9.41	23.75	15.92	0.127

IR, Interquartile range
‡Statistically significant difference between the age groups of 20–39 and 40–59 years (p = 0.006)
§Statistically significant difference between the age groups of 20–39 and ≥60 years (p<0.01).

Examining the general stability values and Fourier indexes of different postures by age group, a statistically significant difference between the age groups of 20–39 and 40–59 years was determined for the F2NC values ($p<0.05$). On the other hand, between the age groups of 20–39 and ≥60 years, statistically significant differences were found for the NCST and F3PO values ($p<0.05$) (Table 2).

In the examination of the trunk flexor and extensor muscle strength values at the rates of 60°/s and 120°/s by age group were, it was found out that there was a statistically signi-

Table 3— Examination of Trunk Muscle Strength Values (nm) By Age Group

Variables	20–39 years		40–59 years		≥60 years		p
	Median	IR	Median	IR	Median	IR	
Flexion at 60 d/s	64.50[‖]	31.00	55.50[¶]	31.50	28.50[‖,¶]	49.25	<0.001
Flexion at 120 d/s	28.00	17.75	30.00	23.75	30.50	25.25	0.717
Extension at 60 d/s	33.50[‖,#]	19.75	27.50[¶,#]	17.00	18.50[‖,¶]	18.25	0.003
Extension at 120 d/s	11.50	9.75	12.00	10.50	11.50	12.75	0.767

IR, Interquartile range

‖Statistically significant difference between the age groups of 20–39 and ≥60 years (p<0.001)
¶Statistically significant difference between the age groups of 40–59 and ≥60 years (p<0.05)
#Statistically significant difference between the age groups of 20–39 and 40–59 years (p<0.05)

ficant decrease in the trunk flexor muscle strength at a rate of 60°/s between the age groups of 20–39 and ≥60 years ($p<0.05$). In addition, statistically significant differences were detected for the trunk extensor muscle strength at 60°/s between the age groups of 20–39 and ≥60 years, 20–39 and 40–59 years, as well as 40–59 and ≥60 years ($p<0.05$) (Table 3).

The correlation coefficients and levels of significance between age and fall indexes, as well as the different posture Fourier indexes and general stability values, exhibited statistically significant differences in F2NC, F3NC, F5NC, F6NC, F3PO, F4PO and NCST stability scores according to age ($p<0.05$). Statistically significant differences were also found between all balance scores and fall index values ($p<0.05$) (Table 4).

Examination of the correlation coefficients and significance levels between the trunk muscle strength indicators and Fourier indexes for different postures and general stability showed statistically significant relations between F4NO, F2NC, F4NC, F5NC, F4PO, NOST, NCST and PCST balance scores and body flexor muscle strength at 60°/s ($p<0.05$). While a statistically significant relationship between the F3PO, F4PO, NCST and PCST balance scores and extensor muscle strength at 60°/s was found ($p<0.05$). Moreover, the extensor muscle score at 120°/s was determined to be statistically significant with only F4PO ($p<0.05$) (Table 5).

Examination and comparison of the correlation coefficients and significance levels between age and fall index, as well as the trunk muscle strength indicators, revealed the presence of a statistically significant difference between the flexor and extensor muscle strength indicators and the age and fall index values ($p<0.05$) (Table 1).

Table 4— Correlation Coefficients and Significance Levels Between The Fall Index and Fourier Indexes for Different Postures and General Stability

Variables	Age		Fall Index	
	r	p	r	p
F1NO	-0.204	0.053	0.237	0.024
F2NO	-0.071	0.505	0.305	0.003
F3NO	0.069	0.517	0.264	0.012
F4NO	0.110	0.301	0.366	<0.001
F5NO	0.016	0.883	0.400	<0.001
F6NO	0.075	0.484	0.470	<0.001
F7NO	0.042	0.691	0.482	<0.001
F8NO	-0.103	0.332	0.305	0.003
F1NC	0.045	0.675	0.289	0.006
F2NC	0.219	0.038	0.394	<0.001
F3NC	0.230	0.029	0.446	<0.001
F4NC	0.155	0.144	0.392	<0.001
F5NC	0.220	0.037	0.437	<0.001
F6NC	0.242	0.021	0.424	<0.001
F7NC	0.151	0.155	0.443	<0.001
F8NC	-0.096	0.367	0.309	0.003
F1PO	-0.136	0.200	0.256	0.015
F2PO	0.157	0.140	0.474	<0.001
F3PO	0.317	0.002	0.432	<0.001
F4PO	0.313	0.003	0.570	<0.001
F5PO	0.123	0.250	0.402	<0.001
F6PO	-0.090	0.401	0.252	0.016
F7PO	0.127	0.233	0.474	<0.001
F8PO	0.077	0.471	0.398	<0.001
F1PC	-0.077	0.472	0.228	0.031
F2PC	0.146	0.170	0.363	<0.001
F3PC	-0.040	0.710	0.358	<0.001
F4PC	0.199	0.060	0.412	<0.001
F5PC	0.051	0.631	0.396	<0.001
F6PC	0.085	0.427	0.235	0.026
F7PC	0.141	0.184	0.387	<0.001
F8PC	-0.072	0.500	0.338	<0.001
NOST	0.122	0.251	0.434	<0.001
NCST	0.294	0.005	0.501	<0.001
POST	0.085	0.427	0.501	<0.001
PCST	0.187	0.078	0.384	<0.001

Table 5— Correlation Coefficients and Significance Levels Between Trunk Muscle Strength Indicators and Fourier Indexes for Different Postures and General Stability

Variables	Flexion at 60 d/s		Flexion at 120 d/s		Extension at 60 d/s		Extension at 120 d/s	
	r	p	r	p	r	p	r	p
F1NO	0.037	0.731	0.040	0.709	0.084	0.433	0.148	0.164
F2NO	-0.185	0.080	-0.149	0.160	0.022	0.839	0.030	0.779
F3NO	-0.144	0.177	-0.026	0.806	-0.056	0.603	-0.092	0.387
F4NO	-0.269	0.010	-0.021	0.846	-0.127	0.232	-0.105	0.325
F5NO	-0.038	0.726	-0.004	0.972	-0.033	0.756	-0.059	0.580
F6NO	-0.100	0.346	-0.008	0.943	-0.015	0.889	-0.012	0.907
F7NO	-0.144	0.177	-0.141	0.185	-0.061	0.571	-0.013	0.902
F8NO	-0.066	0.536	-0.099	0.355	-0.036	0.739	0.015	0.887
F1NC	-0.144	0.177	-0.103	0.333	-0.029	0.785	-0.112	0.294
F2NC	-0.274	0.009	-0.008	0.942	-0.130	0.220	-0.161	0.130
F3NC	-0.184	0.083	0.021	0.847	-0.089	0.402	-0.008	0.938
F4NC	-0.318	0.002	-0.025	0.812	-0.187	0.077	-0.049	0.645
F5NC	-0.271	0.010	0.086	0.421	-0.196	0.064	-0.046	0.665
F6NC	-0.155	0.144	0.195	0.065	-0.108	0.310	0.011	0.917
F7NC	-0.153	0.151	0.078	0.467	-0.121	0.254	-0.028	0.796
F8NC	-0.043	0.690	0.067	0.533	0.072	0.497	0.039	0.712
F1PO	0.040	0.711	-0.005	0.960	0.000	0.998	-0.043	0.686
F2PO	-0.097	0.363	0.017	0.875	-0.156	0.141	-0.050	0.643
F3PO	-0.139	0.191	0.114	0.284	-0.274	0.009	-0.061	0.566
F4PO	-0.306	0.003	0.015	0.890	-0.353	<0.001	-0.216	0.041
F5PO	-0.121	0.256	-0.002	0.982	-0.147	0.167	-0.078	0.467
F6PO	0.079	0.457	0.028	0.794	0.035	0.745	-0.125	0.239
F7PO	-0.139	0.192	-0.022	0.838	-0.158	0.136	-0.059	0.583
F8PO	-0.027	0.798	0.006	0.952	-0.104	0.331	-0.067	0.530
F1PC	-0.053	0.620	-0.040	0.711	0.172	0.105	0.005	0.960
F2PC	-0.178	0.094	-0.054	0.611	-0.159	0.134	-0.008	0.944
F3PC	-0.070	0511	0.038	0.720	-0.110	0.301	-0.039	0.715
F4PC	-0.205	0.052	0.151	0.156	-0.138	0.195	0.072	0.499
F5PC	-0.194	0.067	0.069	0.516	-0.171	0.107	-0.058	0.590
F6PC	-0.134	0.209	0.017	0.871	-0.145	0.172	-0.050	0.642
F7PC	-0.140	0.187	-0.093	0.383	-0.183	0.084	-0.109	0.306
F8PC	-0.029	0.785	-0.082	0.443	-0.017	0.874	-0.174	0.102
NOST	-0.233	0.027	-0.056	0.599	-0.130	0.222	-0.108	0.310
NCST	-0.265	0.011	0.046	0.667	-0.228	0.031	-0.077	0.473
POST	-0.133	0.213	-0.027	0.803	-0.146	0.169	-0.156	0.143
PCST	-0.244	0.020	0.000	0.999	-0.264	0.012	-0.110	0.302

Discussion

There are lots of studies in the literature that focus solely on the effect of age on balance and as a distinct factor. These studies exhibit a common finding that balance deteriorates with ageing and that age is an important factor affecting balance (6-8). Moreover, in our study, a comparison of the measurements of the balance parameters obtained through static posturography between the different age groups indicated that the age group of 20–39 years produced superior F2NC, NCST and F3PO balance scores to those of the other age groups. A statistically significant correlation was found to exist between age and F2NC, F3NC, F5NC, F6NC, F3PO, F4PO and NCST balance scores. This finding indicates that a decrease in balance performance associated with age was found during the eyes closed condition and altered proprioception was found when standing on the pillows. In a previous study, participants whose eyes were closed performed worse on all balance tests than did sighted individuals (9). The more pronounced deficiency in the postural controls during this condition was suggested to exist due to the remaining sensory input systems being more challenged in the absence of visual feedback (10). Extremely accurate vestibular control is required for postural control while standing on pads. Alpini et al. found that in elderly persons, the pads provoke unsteadiness. Thus, under pad conditions, there is a positive correlation between stability and chronological age (8). Unsteadiness and balance disorders depend on the effectiveness of the sensorial cues (e.g. proprioception, somatosensation and vision). The combination of the sensory deficits with advancing age is likely responsible for the postural instability (11).

In a study including 163 healthy controls, Fujimato et al. evaluated the effect of age on postural control. In this study, there was an apparent increase in age-related postural oscillation in 7 patient groups classified using 10-year age increments, with a marked change in the group aged ≥75 years; however, the differences were less prominent in the middle-aged groups (12). The same study acknowledged that there is insufficient knowledge regarding the changes of postural oscillation during the middle-aged individuals. In our study, a greater disruption in the balance parameters was evident in the group aged ≥60 years, but differences between the 40–59- and ≥60-year age groups were not determined. This result highlights the need of using sensitive force platforms to reveal differences in the middle-aged group.

In studies where muscle strength increasing exercise programs are implemented, enhanced balance scores and a decrease in falling frequencies was manifested in line with the increased muscle strength (13,14). Trunk stabilisation is essential for maintaining static and dynamic balance. The apparently simple act of standing motionless is a continuing process of minute adjustments in body position to maintain the centre of gravity over the base of support (15). Attenuation of the trunk paraspinal and abdominal muscles was a significant predictor of standing balance in older adults (16).

In the systematic review of Granacher et al. when the data of the six sectional studies were examined it was reported that there was a small to moderate correlation between muscle composition and balance, functional performance and fall (17). At the same time, although age related lower limb was targeted in the treatment attempts of mobility, balance problems and fall, recently the role of the core stabilization detected in daily activities or/and movements related to sport have also been taken into consideration. Differently from the study we didn't perform postural evaluation in this collection it was detected that the body extensors of the elderly individuals in the kyphotic position proved to be particularly important in terms of balance and mobility. However, the results of our study, in which we found out that trunk flexor and extensor muscle strength and fall risk were related, were consistent with the results emphasizing the importance of trunk muscle strength.

Pradeep et al. demonstrated that the balance and mobility performances of elderly individuals are related to trunk muscle strength and endurance (18). In another study examining the relationship between balance and trunk muscles associated with core stability, it was reported that seated balance performance and trunk muscle responses are the best indicators of core stability (10). In our study, the relationship between trunk muscle strength and balance was assessed on the basis of standing postures.

In our study, it was determined that as age increases, the trunk flexor and extensor muscle strengths at 60°/s decreases, and the trunk flexor muscle strength at 60°/s was statistically significantly correlated with the F4NO, F2NC, F4NC, F5NC, F4PO, NOST, NCST and PCST balance scores. Statistically significant correlations were also found between the extensor muscle strengths at 60°/s and F3PO, F4PO, NCST and PCST balance scores and between the extensor muscle strength at 120°/s and the F4PO balance score. In line with these data and consistent with the findings provided in the literature, it is observed that the decreases in trunk extensor strength and particularly the flexor muscle strength are related to the deterioration in balance parameters. Previously, it was found that at least two control systems: a short-term mechanism and a long-term mechanism, operated during quiet standing (19). Trunk flexor and extensor strength are important for the long-term postural control mechanism. It has also been found that trunk extensor strength training led to an increase in body sway by causing a (neuro)muscular imbalance between the predominantly trained back and hip extensors and the abdominal trunk and hip flexors; thus increasing the open loop central control effort to maintain postural stability (20).

Gemalmaz et al. reported a serious and medium fall risks in 41 (40.6%) and 23 (22.8%) elder subjects, respectively, out of a total of 101 elder subjects (21). In our study, while the fall index values were determined to increase with age, there were also statistically significant differences in the fall index values found between the age groups of 20–39 and ≥60 years, as well as between the age groups of 40–59 and ≥60 years. The prevailing opinion in the literature is that muscle strength decreases with age and results in an increased risk of falling (22). Moreover, in our study, an increase in the risk of falling was determined in relation to the age-related decrease in the body extensor and flexor muscle strength.

When evaluating these data and the results obtained in our study, there were some limitations. Negligence of the status of the lower extremity muscles of the subjects has been a major drawback of this study. The assessment of the trunk muscle strength and balance measurements conducted in our study is limited. When compared with the studies included in the literature, the sample size was relatively small. In addition, with the consideration that there are many factors that affect the risk of falling, the factors that are not included within the scope of our study, including the exercise histories of the participants, their environmental factors, genetic factors and the fear of falling limit our generalisation of the obtained findings.

In conclusion, our findings indicate that progressive deteriorations occur in balance parameters with ageing and that the changes in the somatosensorial and vestibular systems have important effects on balance. Furthermore, increases in fall risk were observed with ageing, and these changes were in line with the decreasing trunk muscle strength, particularly for the trunk flexors.

Older individuals are specific populations who are at the risk of experiencing a large number of factors that may be related to balance disorders and increasing risk of falling. However, it should be noted that apart from the other factors, advancing age and declining trunk muscle strength are associated with balance disorder and the increasing risk of fall. Therefore, in exercise programmes for older individuals to improve balance and increase stabilization, in the targeted muscle groups there should be trunk flexor and extensor muscles.

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