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# Postural Stability in Individuals with Different Levels of Physical Activity: A Preliminary Study

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## ABSTRACT

**Purpose:** To investigate the differences in posture, static, and dynamic balance among young adults with varying levels of physical activity.

**Methods:** A cross-sectional study was conducted with 23 healthy young adults aged 18-29 years. Physical activity levels were assessed using the International Physical Activity Questionnaire -Short Form. Posture was evaluated through a photographic method, and static balance was measured using the FreeMed baropodometric platform. Participants were categorized into inactive, minimally active, and very active groups based on their Metabolic Equivalent of Task-minute/week scores. Balance outcomes were measured through Delta X, Delta Y, and Average surface, including monopodal/bipodal stances, with eyes open/closed.

**Results:** No significant differences in forward head posture were found across groups ($p = 0.630$). However, balance parameters such as Delta X and Delta Y in closed-eye monopodal stances demonstrated significant differences. The very active group showed superior stability in these balance tests in closed-eye monopodal stances ($p < 0.05$).

**Discussion:** The findings of this preliminary study suggest that regular physical activity may be associated with improved balance, particularly in dynamic tasks, as indicated by better stability during closed-eye monopodal balance tests. While no significant differences were found in posture, the results imply that physical activity may enhance proprioceptive control and neuromuscular coordination, potentially contributing to better postural stability. These preliminary results highlight the potential benefits of physical activity for balance and stability, especially in challenging conditions. However, further research is required to confirm these effects and to explore the long-term impact of physical activity on postural control.

**Key words:** posture, balance, physical activity, static balance, physiotherapy

## INTRODUCTION

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (1). A study conducted on the physical activity levels of male individuals in Turkey revealed that 47.7% of Turkish men are physically inactive, 30.4% are minimally active, and only 21.9% are sufficiently physically active (2). Another study indicated that a large portion of the Turkish population does not meet the recommended levels of physical activity, making physical inactivity a widespread problem (3). These findings highlight that the majority of individuals in Turkey are physically inactive.

The issue of physical inactivity significantly affects the adult population, especially the young adults (4). It is thought that factors brought about by modern life, such as technological advancements, internet addiction, and sedentary lifestyles, contribute to this problem (5). For instance, a study on young adults in Turkey found that 22.6% of male students and 49% of female students are not physically active (6). Additionally, another study that assessed the physical activity and internet addiction levels of 638 university students revealed that 28.1% of participants were classified as inactive, and this inactivity showed a positive correlation with internet addiction (7).

Insufficient physical activity has both short- and long-term negative effects on the human body. Chronic conditions such as type 2 diabetes and hypertension are prominent examples of health issues arising from physical inactivity (8). Moreover, a sedentary lifestyle may lead to biomechanical problems, including deterioration in posture and impairments in maintaining static balance, which are critical functions of the body (9).

Posture is a fundamental biomechanical feature that ensures the body is correctly and stably aligned in space (10). A study conducted among school-aged children demonstrated that regular physical activity is effective in reducing postural disorders (11). Postural stability refers to the ability to maintain or control the position of the body within its base of support, ensuring equilibrium during both static and dynamic conditions. It is a key component of balance and relies on the integration of sensory (vestibular, visual, and proprioceptive), neuromuscular, and musculoskeletal systems. Effective postural stability is essential for maintaining upright posture, preventing falls, and adapting to environmental challenges during daily activities and physical performance (12). Static balance refers to the ability to maintain a stable posture against gravity in a stationary position. Previous studies have shown that physically active individuals outperform sedentary ones in static balance tests (13, 14). In contrast, dynamic balance refers to the ability to maintain stability and control the body while it is in motion (15). Evidence suggests that regular physical activity enhances dynamic balance by improving neuromuscular coordination, proprioceptive feedback, and postural control. Activities such as balance training and strength exercises help reduce postural sway, improve reaction times, and enhance movement efficiency, ultimately lowering the risk of falls and improving motor performance (16, 17, 18).

However, there is a notable gap in the literature regarding studies that simultaneously examine these three parameters, including posture and static balance in young adults. Considering the decline in physical activity levels due to factors such as advancing technology and sedentary lifestyles (19), evaluating these parameters together in young adults could address a significant research gap. This study aims to investigate the differences in posture and static balance among young adults with varying levels of physical activity.

Research hypotheses are: H0: There is no significant difference in posture, static balance, and dynamic balance among young adults with different physical activity levels and, H1: There are significant differences in posture, static balance, and dynamic balance among young adults with different physical activity levels.

## METHODS

### Study Design

The present study was designed as a cross-sectional research project. It was conducted at the Faculty of Physical Therapy and Rehabilitation at Hacettepe University. The study protocol received approval from the Hacettepe University Faculty of Physical Therapy and Rehabilitation Research Ethics Committee (FTREK24/44). All participants were fully informed about the study's objectives and the planned measurements before participation. Written informed consent was obtained from each participant.

### Participants

Participants were recruited through social media platforms and advertisements for the study, which included 23 healthy young adults meeting specific eligibility criteria. To qualify, participants had to be between 18 and 29 years old, willing to participate, and have a Mini-Mental State Examination (MMSE) score of 24 or higher to ensure normal cognitive function (20). Individuals who refused to provide voluntary consent or who had conditions such as congenital or acquired spinal deformities, disc herniation, cervical disc issues, neurological disorders, vestibular problems, or musculoskeletal diseases, and any known cardiovascular conditions that could pose a risk during physical activity were excluded from the study.

### Outcome Measures

Sociodemographic information was collected, which included participants' age, body mass index (BMI), gender, and education.

**Physical Activity Level Outcomes**

The "International Physical Activity Questionnaire - Short Form (IPAQ)" was utilized to evaluate physical activity levels. This questionnaire has been validated for reliability and validity in Turkish and provides insights into the time spent on vigorous and moderate activities, as well as walking. Notably, the last question addresses sitting time separately and is excluded from the overall calculation (21, 22).

The questionnaire consists of four sections and seven questions. Questions 1 and 2 assess the time spent on vigorous physical activities; questions 3 and 4 cover moderate physical activities; questions 5 and 6 focus on walking, and question 7 inquiries about sitting time. Participants were asked about the physical activities they engaged in over the past seven days, with response options including: Did not do/Don't know/Unsure/Days per week … /minutes per day … /hours per day. It was emphasized that each activity must be performed for at least 10 minutes at a time (23).

Physical activity level has been determined using daily and weekly Metabolic Equivalent of Task (MET)-minute calculations. The MET values assigned to each type of activity were used, and the activity duration (in minutes) and frequency (in days) were multiplied. The MET value for walking is 3.3, for moderate physical activity is 4.0, and for vigorous activity is 8.0. MET-minute/week calculations for each activity type are as follows: Walking MET-minute/week = 3.3 x walking minutes x walking days, moderate MET-minute/week = 4.0 x moderate activity minutes x moderate activity days, vigorous MET-minute/week = 8.0 x vigorous activity minutes x vigorous activity days. The total MET-minute/week is obtained by summing the MET-minute/week scores for all activities. The resulting MET-minute/week value is used to determine the individual's physical activity level. Physical activity levels are divided into three categories: *'inactive group' (category 1), 'minimally active group' (category 2), and 'very active group' (category 3).* The *inactive category* defines individuals with low activity levels. *Minimally active* individuals are those who engage in at least 3 days of 20 minutes of vigorous activity, or at least 5 days of 30 minutes of moderate activity, or achieve 600 MET-min/week. *Very active* individuals engage in at least 3 days of 1500 MET-min/week of vigorous activity, or 7 days of 3000 MET-minute/week combining walking, moderate, and vigorous activities. This methodology helps determine individuals' physical activity levels and supports the achievement of health benefits (24).

**Posture**

The assessment of individuals' forward head posture was conducted using photographs taken from the sagittal plane. Reflective markers were strategically placed on specific anatomical points, and participants were positioned in front of a posture board. Images were captured for analysis using a smartphone placed on a tripod one meter away. These photographs were then independently analyzed using DIGIMIZER software to determine the average angles related to head and neck posture. Forward head posture was evaluated by calculating the angle between the line from the tragus to the C7 spinous process and a vertical line from the C7 spinous process, using a threshold of ≥ 46°. Each angle was measured twice by an experienced physiotherapist to reduce bias (25).

**Balance Outcomes**

The FreeMed baropodometric platform (Sensor Medica, Rome, Italy) was utilized to assess static and dynamic balance outcomes. This platform measures 60 cm x 50 cm and operates with Free Step software, featuring a sampling frequency of 400 Hz. The static balance metrics included sway in the X (mediolateral) and Y (anteroposterior) axes, referred to as DeltaX and DeltaY, which were measured over a 20-second period, while the sway velocity (AVsurface) was measured dynamically over 1 minute." (Matla, Filar-Mierzwa et al., 2021). DeltaX
and DeltaY were recorded in millimeters, while Avsurface was expressed in square meters. All static balance outcomes were evaluated with the eyes open (OE) and closed (CE), as well as in monopodalic (MP) (left/right) and bipodalic (BP) stances.

Before all measurements, participants were gradually given instructions as follows: *1) 'OE-Bipodalic', 2) 'CE-Bipodalic', 3) 'OE-Monopodalic-Left', 4) 'OE-Monopodalic-Right', 5) 'CE-Monopodalic-Left', 6) 'CE-Monopodalic-Right'.*

The AVsurface assessment aimed to analyze participants' interactions with a baropodometric platform, measuring average surface sway and pressure distribution. As part of the dynamic evaluation, the FreeMed platform collected data on pressure distribution and movement from foot contact areas. Participants walked at least 10 gait cycles on a 150 cm-long walking platform for each leg. Additional passive platforms extended the active panel by supporting the walking platform. Measurements were recorded in seconds.

### Statistical Analysis

Data were analyzed using the SPSS software (version 21). The normality of the data was assessed using the Shapiro-Wilk test. Descriptive statistics for continuous variables were expressed as means ± standard deviation (X ± SD). Categorical variables were presented as frequencies and percentages.

To compare postural and balance parameters among the inactive, minimally active, and very active groups, the Kruskal-Wallis test was applied for non-normally distributed data. Post hoc pairwise comparisons were performed using the pairwise Kruskal-Wallis test. Pairwise comparisons were conducted using the Mann-Whitney U test with appropriate adjustments for multiple comparisons. Statistical significance was set at $p < 0.05$. Data are presented as median (IQR) for non-normally distributed data, with significance levels indicated as follows: $p^1$ for comparisons between the inactive and minimally active groups, $p^2$ for comparisons between the inactive and very active groups, and $p^3$ for comparisons between the minimally active and very active groups. Post hoc analyses were performed with the p-value adjusted to 0.017 using the Bonferroni correction to account for multiple comparisons.

A post hoc power analysis was conducted to evaluate the adequacy of the sample size in detecting differences among the groups for the Delta Y (CE-Monopodalic-L) parameter. The effect size (Cohen's $f$) was calculated as 1.48, indicating a large effect. With a total sample size of 23 participants (inactive group: $n$=8, minimal inactive group: $n$=9, very active group: $n$=6) and a significance level ($\alpha$) of 0.05, the achieved power was approximately 1.00 (99.9%). These results suggest that the study was sufficiently powered to detect differences among the groups for this variable.

## RESULTS

The demographic and physical activity characteristics of participants are summarized in Table 1. No significant differences were observed in age (p = 0.131), BMI (p = 0.069), or education levels (p = 0.327) among the inactive, minimally active, and very active groups. Physical activity levels, measured by IPAQ, were significantly higher in the very active group (6220.0 ± 4125.28 minute/week) compared to the minimally active (1744.56 ± 970.51 minute/week) and inactive groups (308.75 ± 163.44 minute/week, p = 0.018).

**Table 1.** Comparison of Demographic and Physical Activity Characteristics Among Inactive, Minimally Active, and Very Active Groups

| Variables X±SD (Min-Max) | Inactive group (n=8) | Minimally active group (n=9) | Active group (n=6) | p |
|---|---|---|---|---|
| **Age (years)** | 22.0 ± 2.07 (18-24) | 23.78 ± 1.98 (21-28) | 24.0 ± 1.41 (22-26) | 0.131 |
| **Body Mass Index (kg/cm2)** | 20.87± 2.17 (17.41-23.77) | 20.84±2.19 (17.50-24.58) | 24.20±3.23 (20.57-28.30) | 0.069 |
| **IPAQ (minute/week)** | 308.75±163.44 (80-594) | 1744.56±970.51 (693-2986) | 6220.0±4125.28 (2782-14238) | **0.018** |
| **Gender n (%)** | | | | |
| Female | 0 | 5 | 4 | **0.005** |
| Male | 8 | 4 | 2 | |
| **Education n (%)** | | | | |
| High school | 4 | 2 | 1 | 0.327 |
| Bachelor degree | 4 | 7 | 5 | |

X±SD:Mean±Standard deviation, Min:minimum, Max:maximum, IPAQ: International Physical Activity Questionnaire

**Table 2.** Comparison of Postural and Balance Parameters Among Inactive, Minimally Active, and Very Active Groups

| Variables | Inactive group (n=8) Median (IQR) | Minimally active group (n=9) Median (IQR) | Very Active group (n=6) Median (IQR) | p[a] | p[1] | p[2] | p[3] |
|---|---|---|---|---|---|---|---|
| **Forward head posture (°)** | 57.50 (53.50-63.50) | 54.0 (52.0-67.0) | 53.50 (50.75-59.0) | 0.630 | - | - | - |
| **Delta X (mm)** | | | | | | | |
| OE-Bipodalic | 2.70 (1.81-6.75) | 4.02 (2.88-6.25) | 4.38 (2.96-6.56) | 0.618 | - | - | - |
| CE-Bipodalic | 2.47 (2.06-4.74) | 2.72(2.13-3.88) | 3.40 (2.47-5.86) | 0.636 | - | - | - |
| OE-Monopodalic-L | 9.52 (6.73-13.38) | 10.34 (6.42-18.12) | 11.06 (8.40-13.63) | 0.825 | - | - | - |
| OE-Monopodalic-R | 16.36 (11.13-17.92) | 14.79 (11.56-16.64) | 10.95 (8.82-13.68) | 0.109 | - | - | - |
| CE- Monopodalic-L | 36.73 (25.31-42.99) | 28.92 (25.25-41.68) | 22.25 (20.86-25.58) | **0.037** | 0.613 | **0.014** | 0.040 |
| CE- Monopodalic-R | 32.19 (23.10-46.21) | 29.12 (24.22-24.84) | 14.92 (11.74-18.79) | 0.088 | - | - | - |
| **Delta Y (mm)** | | | | | | | |
| OE-Bipodalic | 3.42 (1.95-5.02) | 3.60 (2.56-4.37) | 3.69 (2.98-8.65) | 0.651 | - | - | - |
| CE-Bipodalic | 2.93 (2.50-5.69) | 4.61 (2.31-5.08) | 4.09 (2.66-5.76) | 0.790 | - | - | - |
| OE-Monopodalic-L | 12.61(10.61-18.15) | 12.34 (11.11-22.91) | 14.92 (11.74-18.79) | 0.642 | - | - | - |
| OE-Monopodalic-R | 13.57 (10.02-16.80) | 17.58 (15.24-24.74) | 16.05 (14.09-22.37) | 0.064 | - | - | - |
| CE- Monopodalic-L | 37.37 (29.08-53.23) | 43.33 (36.88-63.46) | 21.76 (20.92-24.07) | **0.012** | 0.680 | **0.016** | **0.005** |
| CE- Monopodalic-R | 39.11 (30.90-47.71) | 39.86 (27.11-69.02) | 26.60 (24.01-27.89) | **0.012** | 0.655 | **0.005** | **0.014** |
| **AVsurface ($m^2$)** | | | | | | | |
| Left | 77.75 (64.02-96.18) | 77.0 (67.21-84.33) | 77.54 (66.17-86.5) | 0.980 | - | - | - |
| Right | 78.35 (67.68-87.87) | 74.88 (70.34-86.56) | 79.95 (70.61-92.35) | 0.855 | - | - | - |

OE: Open Eyes, CE: Closed Eyes, L: Left, R: Right, AV: Average, [a]Kruskal Wallis Test confirmed the differences among groups. [b]Pairwise Test confirmed the differences between inactive, minimally active, and active groups
p1: Post hoc analyses indicated differences in inactive group compared to minimally active group.
p2: Post hoc analyses indicated differences in inactive group compared to very active texting.
p3: Post hoc analyses indicated differences in minimally active group compared to very active group.

Table 2 summarizes the comparison of posture and balance parameters among inactive, minimally active, and very active groups. No significant differences were observed in forward head posture (p = 0.630).

For balance parameters, Delta X (CE-Monopodalic-R) was significantly different among groups (p = 0.037), with post-hoc analysis showing differences between the minimally active and very active groups (p3 = 0.04). Delta Y (CE-Monopodalic-L and CE-Monopodalic-R) demonstrated significant group differences (p = 0.012 for both). Post-hoc analysis revealed differences between inactive and very active groups (p2 = 0.016 and p2 = 0.005) and between minimally active and very active groups (p3 = 0.005 and p3 = 0.014). No significant differences were observed in Delta X (OE-Bipodalic-R and OE-Bipodalic-L) (respectively; p= 0.618, p =0.636) and Delta Y (OE-Bipodalic-R and OE-Bipodalic-L) (respectively; p= 0.651, p =0.790).

For average surface area (AVsurface), no significant differences were observed across groups for either side (p = 0.980, p = 0.855).

## DISCUSSION

This preliminary study aimed to compare postural stability, including posture and balance parameters, among individuals with varying levels of physical activity. Although no significant differences were found in postural parameters (such as forward head posture) and AVsurface, key balance parameters such as Delta X (mediolateral sway, CE-Monopodalic-R) and Delta Y (anteroposterior sway, CE-Monopodalic-L and CE-Monopodalic-R) showed significant group differences, with the very active group demonstrating superior stability. On the other hand, mediolateral and anteroposterior sway during monopodalic stances did not show significant differences among the inactive, minimally active, and very active groups.

Multiple factors could contribute to the absence of postural differences in individuals with different physical activity levels. Posture can be affected by many factors. A meta-analysis study indicated that there was no significant association between physical activity and human posture (26). Posture is a complex phenomenon involving many factors, including genetics, age, and musculoskeletal factors

(27). While it is generally assumed that physical activity and exercise can improve posture, the evidence is mixed regarding the specific benefits for posture enhancement. Some studies have shown modest improvements in posture after engaging in certain exercises, while others have found little to no significant change. The effectiveness seems to depend on the type of exercise, the duration and frequency of the program, and individual factors such as body type and existing postural habits (28, 29).

Additionally, forward head posture is influenced by environmental factors, including prolonged sitting, computer use, and poor postural habits, as well as genetic factors (30, 31). This suggests that even active individuals may encounter postural deviations such as forward head posture. While the positive effects of physical activity on overall health are well known, it could be considered that specific and targeted exercises are necessary to correct forward head posture (32, 33). For example, general activities like cardiovascular exercises may be insufficient to correct forward head posture. In this context, it is understood that simply having a higher level of physical activity does not lead to significant improvement in forward head posture. Instead, a focused and consistent exercise program is required to address postural disorders. Therefore, the effect of physical activity on forward head posture may be more effectively assessed through more comprehensive and individualized interventions. More research is needed to fully understand the complex relationship between physical activity and postural improvement.

The differences in balance parameters among very active individuals can be attributed to the benefits of regular physical activity, which enhances neuromuscular coordination, proprioception, and core muscle strength (34). Mediolateral and anteroposterior sway may be more sensitive indicators of balance, as they measure specific aspects of static stability. These parameters might have been able to detect subtle differences that general postural parameters could not. Changes in the support surface, visual input changes, or more complex body configurations, such as more challenging postural tasks, can accentuate differences in individuals' postural responses. Particularly in complex tasks like single-leg stances or visual impairments, individuals may show greater variability and slower responses (35). Exercise contributes to both correcting displacement by enhancing muscle strength, balance, coordination, and reaction time and improving the perception of displacement by reducing edema and increasing range of motion, which collectively enhance proprioception and sensation (36). A study has shown that regular physical activity strengthens proprioceptive abilities and neuromuscular coordination, which are essential for maintaining stability in single-leg stances (37). Furthermore, the proprioceptive system provides sensory feedback about body position and movement through receptors in muscles, tendons, and joints. This information is critical for maintaining balance, especially when visual input is removed, as in closed-eye conditions (38). These findings align with the results of the present study, as the very active group tended to exhibit better stability, which may suggest improved sensorimotor integration and control strategies.

The lack of a significant relationship between the AVsurface (average surface area) parameter and physical activity levels may indicate that this parameter does not adequately reflect the differences in physical activity levels. While AVsurface reflects the area necessary to maintain balance, it could be argued that differences in physical activity levels do not create a significant change in this parameter. One possible reason for this could be that AVsurface does not fully reflect all the factors affecting balance. Although this parameter represents a broader area for maintaining balance, the direct effect of physical activity on this parameter may be limited. This parameter may have a lower sensitivity to different types of physical activity.

**Limitations**

The study's findings must be interpreted with caution due to potential limitations such as small sample size, heterogeneity in physical activity levels, and reliance on specific balance parameters. Future studies should consider longitudinal designs to explore causal relationships and include a broader range of postural and balance measures to provide a more comprehensive assessment of stability. Additionally, incorporating other factors, such as cognitive load or dualtask conditions, may help elucidate the complex interplay between physical activity and balance control.

## CONCLUSION

As a preliminary study, these findings suggest that while higher physical activity levels may contribute to better balance, their impact on posture remains unclear. General postural parameters showed no significant differences, indicating that physical activity alone may not be sufficient for postural improvements. Targeted exercises might be more effective in addressing postural deviations. However, further research with larger sample sizes and comprehensive assessments is needed to better understand the relationship between physical activity, posture, and stability.

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