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ORIGINAL ARTICLE

การยืนขาเดียวลืมตาบนพื้นโฟม สามารถแยกแยะความสามารถในการทรงตัวในวัยรุ่น

อรษา แสนโน[1, 3], ลักขณา มาทอ[2], ทกมล หรรษาวงศ์[2, 3], วัณทนา ศิริธราธิวัตร[2, 3]*

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บทคัดย่อ

ระดับของการมีกิจกรรมทางกายเป็นปัจจัยอย่างหนึ่งที่ส่งผลต่อความสามารถด้านการทรงตัวในวัยรุ่น การแข่งขันทางด้านการศึกษาที่สูงและการเข้าสู่ยุคสังคมออนไลน์ทำให้วัยรุ่นมีแนวโน้มที่จะมีกิจกรรมทางกายลดลง และมีพฤติกรรมเนือยนิ่งเพิ่มสูงขึ้น งานวิจัยที่ทำการเปรียบเทียบความสามารถในการทรงตัวในวัยรุ่นที่ไม่ใช่นักกีฬาแต่ยังคงมีกิจกรรมทางกายกับผู้ที่มีพฤติกรรมเนือยนิ่งนั้นยังมีจำกัด การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบความสามารถในการทรงตัวขณะยืนขาเดียวในวัยรุ่นที่มีระดับกิจกรรมทางกายต่างกัน ทำการศึกษาในอาสาสมัคร 90 คน อายุเฉลี่ย ± ส่วนเบี่ยงเบนมาตรฐาน = 14.4 ± 1.4 ปี ในกลุ่มที่มีกิจกรรมทางกายและ 14.7 ± 1.5 ปี ในกลุ่มที่มีพฤติกรรมเนือยนิ่ง อาสาสมัครได้รับการประเมินระดับการมีกิจกรรมทางกายโดยใช้แบบสอบถามการมีกิจกรรมทางกายใน 7 วันที่ผ่านมา อาสาสมัครที่มีกิจกรรมทางกายน้อยกว่า 600 นาทีต่อสัปดาห์ได้รับการจัดให้อยู่ในกลุ่มที่มีพฤติกรรมเนือยนิ่ง อาสาสมัครทั้งหมดได้รับการทดสอบความสามารถด้านการทรงตัวขณะยืนขาเดียวหลับตาและลืมตาบนพื้นราบและพื้นโฟมด้วยขาข้างที่ถนัด 4 สถานการณ์ ผลการศึกษาพบว่า อาสาสมัครกลุ่มที่มีกิจกรรมทางกายยืนทรงตัวบนขาข้างเดียวได้นานกว่ากลุ่มที่มีพฤติกรรมเนือยนิ่งอย่างมีนัยสำคัญทางสถิติใน 3 สถานการณ์ ได้แก่ ยืนหลับตาบนพื้นราบ และยืนลืมตาและหลับตาบนพื้นโฟม ($p < 0.05$) สรุปผลการศึกษา อาสาสมัครกลุ่มที่มีกิจกรรมทางกายยืนบนขาข้างที่ถนัดได้ดีกว่ากลุ่มที่มีพฤติกรรมเนือยนิ่ง และการทดสอบยืนขาเดียวลืมตาบนพื้นโฟม สามารถแยกแยะระดับการทรงตัวในวัยรุ่นได้

คำสำคัญ: การทรงตัว, กิจกรรมทางกาย, วัยรุ่น

[1]นักศึกษาปริญญาโท สาขาวิชากายภาพบำบัด คณะเทคนิคการแพทย์ มหาวิทยาลัยขอนแก่น
[2]สายวิชากายภาพบำบัด คณะเทคนิคการแพทย์ มหาวิทยาลัยขอนแก่น
[3]ศูนย์วิจัยปวดหลัง ปวดคอ ปวดข้ออื่นๆ และสมรรถนะของมนุษย์ คณะเทคนิคการแพทย์ มหาวิทยาลัยขอนแก่น
*ผู้รับผิดชอบบทความ

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ORIGINAL ARTICLE

Single Leg Stance on a Foam Surface with Eyes Open can Differentiate Balance Performance in Adolescents

Aurasa Saenno[1, 3], Lugkana Mato[2], Torkamol Hunsawong[2, 3], Wantana Siritaratiwat[2, 3]*

Abstract

Level of physical activity is one of the factors affecting postural stability among adolescents. Using social media and high competitive education lead to prolonged sitting and adolescents tend to have increasing sedentary behavior. However, evidence reporting postural stability in asymptomatic adolescents who are not involved in sports training is still limited. The purpose of this observational study was to compare postural control during one-leg standing between adolescents who were physically active and sedentary. Ninety school-aged adolescents with a mean age ± SD of 14.4 ± 1.4 years in physically active group and 14.7 ± 1.5 years in sedentary group were recruited. All participants were asked about their demographic data and physical activity behavior during the past 7 days. The participants who had metabolic equivalent scores less than 600 minutes per week were classified as a sedentary group. One-leg standing on the dominant side with eyes open and eyes closed on a firm surface and a balance pad were performed in all participants. The results showed that the participants in the physically active group had a significantly longer time of one-leg stance than the sedentary group in 3 conditions: eyes-closed on firm surface, eyes-open and eye-closed on the balance pad ($p < 0.05$). In conclusion, participants who are physically active perform significantly better at postural stability measured by a single-leg stance than those in the sedentary group. One-leg stance with eye open on the balance pad can differentiate the postural stability in adolescents.

Keywords: Postural control, Physical activity, Adolescents, Sedentary

[1]Master Degree Student, School of Physical Therapy, Faculty of Associated Medical Sciences
[2]School of Physical Therapy, Faculty of Associated Medical Sciences, Khon Kaen University
[3]Research Center in Back, Neck, Other Joint Pain and Human Performance (BNOJPH), Khon Kaen University
*Corresponding author (e-mail: wantana.siritaratiwat@gmail.com)

INTRODUCTION

Physical activity is one essential factor promoting growth, development and postural control among adolescents. As growth rate and development of postural control continues in an ongoing process during adolescence, before reaching its maturation in an adult-like stage, insufficient physical activity may impede development of postural stability among adolescents[1]. Evidence showing a very high prevalence of leisure physical inactivity at 80.4% and sedentary behavior at 33.0% were reported among 30,284 school children aged from 13-15 years in Southeast Asian Nations (ASEAN) Member States including Thailand[1]. Moreover, the Thai Health Promotion Foundation found that Thai people in generation Y who were born from 1982 to 2005 spend one-third of the day or 13.4 hours per day on social media[2].

Research has shown that postural stability can be affected by level of physical activity in daily living[3]. Adolescents with sports training exhibit better postural control performance compared with those with physical inactivity[4, 5]. Giagazoglou et al. suggested that not only active physical activity, but also muscle strength is essential for an individual's posture control in the upright position, especially in ankle, knee, and hip muscles[6]. These previous studies investigated postural control, using laboratory instruments, in participants who were grouped as athletes and non-athletes, and studies clearly confirmed that postural control performance can be attributed to the level of sport training[3, 4].

However, functional tests reducing limitations of cost and time would be appropriate for measuring balance in a large population in a community setting. A standing balance test is recommended for use for examination of the postural stability, which is similar to the laboratory balance test[7]. The single-leg stance test is a clinical balance test which requires information from different sensory systems including somatosensory, visual and vestibular systems. Moreover, the single-leg stance can simultaneously examine functional muscle strength in lower extremities such as ankle, knee and hip muscles[8]. In order to control posture during walking independently and in daily activity, the single-leg support phase is necessary to allow the swing phase mechanics of the opposite leg. Therefore, to measure the ability to control the body's center of mass within the base of support during standing on one leg is useful for functional balance measures[9].

Even though non-athlete adolescents are asymptomatic or have no impairment of the neuromuscular system, having different physical activities in their daily life, they may have different capacities to control postural stability. Moreover, data about postural stability using the clinical balance test in adolescents who have different physical activity levels is still limited. A single-leg stance protocol is hypothesized to be appropriate and is challenging for balance assessment in school-aged adolescents. Moreover, the test can be set in different situations of disturbing sensory inputs when performing the testing on a firm surface or a balance pad with eyes open or eyes closed[10-12]. The one-leg standing balance test was chosen for this study since the test uses minimal equipment, but with different test situations, it can be a challenging task for asymptomatic adolescents. We questioned what condition of single leg stance could differentiate the postural stability among asymptomatic adolescents. The purpose of this current study was to compare postural stability during different conditions of one-leg standing and sedentary.

METHODS

Participants

This cross-sectional study was conducted at two secondary schools in Khon Kaen province, Thailand. Healthy students from 7^{th} – 12^{th} grade were invited to participate in the study. The study was approved by the Khon Kaen University Ethics Research Committee (HE592220). The Head of each secondary school was contacted and asked for permission to collect data. The students were then called to meet face to face to inform them of the objectives and procedure of the study. Students who were interested in joining the research gave their assent and acquired their parents' permission before their participation in this study, and a consent form was signed.

Inclusion criteria were adolescents aged from 13-18 years, able to follow researchers' commands, and having good communication and cooperation. The participants were excluded if they had a history of vertigo or dizziness within 24 hours before testing, being diagnosed as having vestibular or neurological disorders, uncorrected visual problems, use of medications that affect the balance system such as dimenhydrinate, having hearing problems such as hearing loss or use of hearing aids, having history of acute or chronic ear infections, or previous head or limb injuries/operation influencing postural control during standing or walking.

The number of participants were calculated by G*power version 3.1.9.2(13) using mean and standard deviation of variability of postural stability parameter in medial/lateral plane measured by AMTI (Accusway) force plate from a previous study(3). The power of test is set at 0.80 and the significance level was lower than 0.05 ($Z_{\alpha/2}$ = 1.96). From the calculation, 46 participants for each group and a total of 92 participants were required in this study.

Instrument

Modified Thai Adolescents Physical Activity Questionnaire (MTAPAQ)

The Modified Thai Adolescents Physical Activity Questionnaire (MTAPAQ) is a seven-day physical activity recall questionnaire including 37 items that are classified into the group of sedentary behaviour (group I) and seven groups of physical activity (groups II–VIII). Group I activities involve sitting quietly such as watching TV. Group II are games and free-play involving sitting such as arts and crafts, chess, and jigsaw puzzles. Group III are games and free-play involving movement or unstructured outdoor play such as hide and seek. Group IV are exercises involving jumping and standing. Group V is walking. Group VI are sports such as soccer, tennis and volleyball. Group VII includes household activity such as doing the laundry, and Group VIII includes transportation physical activity such as cycling to or from school(13). The MTAPAQ was used to measure physical activity in Thai adolescents aged 12 to 18 years and shows moderate concurrent validity (r = 0.59, *p* = 0.01) with the results of the ActiGraph accelerometer(14). Researchers asked permission to use the MTAPAQ from the developer(14) before data collection began.

Recruited participants were classified into two groups, physically active (PA) and sedentary behaviour (SB) groups, based on their level of physical activity. To classify the level of physical activity, this study used the metabolic equivalent (MET) value of walking, moderate and vigorous activities to calculate the MET scores according to Bauman and colleagues[15]. The values of MET in these activities were walking = 3.6[14], moderate activities = 4.0 and vigorous activities = 8.0[16]. In this study, the participants who had 5 days of any combination of walking and moderate intensity activity achieving at least 600 MET minutes per week were classified into a PA group, according to one of the criteria suggested by Bauman et al., and those with a MET score of less than 600 MET minutes per week were assigned to an SB group[15].

Single leg stance test

Unipedal standing postural control tests with eyes open and eyes closed were performed on a firm surface and a balance pad, an Airex balance pad with a high-density, closed-cell foam pad (50 × 41 × 6 cm). The tests were started with the eyes-open and followed by the eyes-closed condition. During the unipedal stance test, participants were asked to stand on one leg barefoot, arms placed beside the body, not reaching or stepping. If a participant showed loss of postural control such as lifting the arms for balance, touching the foam or floor with the non-weight bearing foot, moving the weight-bearing foot from the starting position, opening eyes in the eyes-closed condition, or the balance pad was moved from its original position, the test was then stopped immediately, which indicated the end of one trial[11]. Participants with a longer time of one-leg standing are those with good standing postural control. The maximum time allowed for each test was 180 seconds[11]. We evaluated the intra-rater reliability of tests in 10 participants aged 24 years for all conditions of standing on one leg and $ICC_{(3,1)}$ values ranged from 0.87 to 0.98 (95% CI; 0.46 – 0.99).

Procedure

All participants were asked to fill in the questionnaire regarding their demographic data and physical activity behavior during the past 7 days. Participant's demographic data included age, weight, height, the frequency, duration and type of physical activity. Physical activity behavior was recorded using the MTAPAQ[14]. It took 15 minutes to finish the questionnaire.

Participants who passed the inclusion criteria performed the unipedal standing tests. The assessment of postural control was conducted in a quiet room. The researchers ensured participant's safety by standing beside the participant within reaching distance of the participants. A practice session on a balance pad was allowed prior to the start of the test. There were 4 conditions of unipedal standing test with the dominant leg. Two conditions were tested on a firm surface and two conditions used the Airex balance pad[11]. Three trials were performed for each condition. The participants could rest during each trial as much as they needed until comfortable to continue with the tests. All administration times were 15-20 minutes for each participant.

Data Analyses

All analyses were conducted using Statistical Package for Social Sciences (SPSS) version 17.0. Data were tested for normality using the Shapiro-Wilk test. A Mann-Whitney U test was used to examine the differences of maximum time in seconds of standing balance between both groups. All variables of unipedal standing balance were reported with mean, standard deviation and 95% confidence interval (95% CI). *P*-value of 0.05 was set for significant differences. The relationship of unipedal standing times and MET minutes per week was examined using Pearson correlation coefficient.

RESULTS

Two hundred and twenty-one healthy school adolescents (67 males, 154 females) aged from 13-18 years from 2 secondary schools in Khon Kaen province agreed to join the study. One hundred participants were excluded due to various reasons such as having a history of vertigo or dizziness within 24 hours before testing, having been diagnosed by a clinician as having vestibular disorders, uncorrected visual problems, having had previous injury or an operation involving poor balance while standing, pain in lower limb while standing or hearing problems, and the remaining 121 students (36 males, 85 females) were eligible for the evaluation of postural control performance. However, only 93 participants could finish the postural control tests. Three participants were excluded from data analysis due to their ability to maintain standing postural control longer than 180 seconds in some conditions of the test. Finally, data from 90 participants (20 males, 70 females) were analyzed.

Demographic data from all participants including sex, age, weight, height, body mass index, and MET minutes per week were reported with mean ± SD (95% CI) as shown in **Table 1**. **Table 2** shows time of unipedal standing conditions between two groups. Participants in the PA group had significantly longer time of unipedal standing than the SB group in 3 conditions: eyes-closed on firm surface, eyes-open and eyes-closed on balance pad ($p < 0.05$). Since the PA group showed wide range of their levels of physical activity (min – max: 1,128 – 19,938), we thus performed sub-group analysis by classify the PA group into moderate (5 days of any combination of walking, moderate intensity activity achieving at least 600 MET minutes per week)[15] and vigorous physical activity (> 5 days of any combination of walking, moderate intensity activities achieving at least 3000 MET minutes per week)[15]. **Table 3** shows sub-group analysis of time of unipedal standing postural control testing between vigorous physical activity (Vig) group and physical inactivity (PI) group. Participants in the Vig group had significantly longer time of unipedal standing than the PI group in all conditions. Moreover, **Table 4** shows significant correlation between level of physical activity (MET minutes per week) and each unipedal standing balance conditions.

Table 1. Demographic data of all participants (Mean ± SD)

Characteristic	PA group (N = 54)	SB group (N = 36)
Age (y)	14.4 ± 1.4	14.7 ± 1.5
Sex (M/F)	16/38	4/32
Weight (kg)	52.2 ± 11.8	54.6 ± 17.3
Height (cm)	159.2 ± 8.5	160.8 ± 5.9
Body mass index (kg/m^2)	20.4 ± 3.7	20.93± 5.4
Physical activity (MET/min/week)	5,460 ± 4,399.5 (min – max: 1,128 – 19,938)	488.9 ± 102.3 (min – max: 201.6 – 600)

Table 2. Results of the time in second performed the unipedal standing postural control testing on dominant leg

Conditions	Mean ± SD of time (second) in PA group (n = 54)	Mean ± SD of time (second) in SB group (n = 36)	Mean difference between groups	*p-value*
Firm surface				
- Eyes-open	122.06 ± 40.35 (112.70 – 139.17)	105.28 ± 42.28 (90.97 – 119.59)	16.78 (-1.03 – 34.58)	0.066
- Eyes-closed	26.86 ± 18.61 (21.61 – 36.01)	18.14 ± 12.27 (13.98 – 22.29)	8.72* (2.25 – 15.19)	0.006
Foam surface				
- Eyes-open	48.74 ± 33.32 (39.81 – 62.12)	25.56 ± 18.12 (19.43 – 31.69)	23.18* (11.09 – 35.27)	0.001
- Eyes-closed	5.01 ± 2.28 (4.27 - 5.78)	3.80 ± 1.59 (3.26 - 4.33)	1.22* (0.35 – 2.01)	0.021

* Significant difference at *p-value* less than 0.05

Table 3. Results of unipedal standing postural control testing between vigorous physical activity (Vig) group and physical inactivity (PI) group

Conditions	Vig group n = 37	PI group n = 36	Mean difference between groups	*p-value*
Firm surface				
- Eyes-open	118.61 ± 41.43 (109.01 – 128.20)	97.10 ± 39.53 (87.81 - 106.39)	21.51 (8.26 – 34.75)	0.002*
- Eyes-closed	30.02 ± 20.41 (25.29 – 34.75)	17.89 ± 14.04 (14.59 - 21.19)	12.13 (6.39 – 17.88)	0.001*
Foam surface				
- Eyes-open	49.19 ± 33.01 (41.54 – 56.84)	24.42 ± 17.15 (20.39 - 28.45)	24.77 (16.13 – 33.41)	0.001*
- Eyes-closed	5.12 ± 2.57 (4.52 - 5.71)	3.91 ± 1.75 (3.50 - 4.33)	1.20 (0.48 – 1.93)	0.001*

* Significant difference at *p-value* less than 0.05

Table 4. Correlations between MET minutes per week and all variables on dominant leg

Independent variable	MET score r# (*p-value*)
Eyes-open static balance	0.211 (0.046)*
Eyes-closed static balance	0.373 (0.001)*
Eyes-open dynamic balance	0.419 (0.001)*
Eyes-closed dynamic balance	0.214 (0.043)*

The relationship (r) of unipedal standing postural control times and MET minutes per week was examined using Pearson correlation coefficient.

* Significant difference at *p-value* less than 0.05

DISCUSSION

The purpose of this study was to compare postural stability during different conditions of the one-leg stance between adolescents who are physically active (PA) and sedentary (SB). We found significantly longer time of standing postural control in the PA groups ($p < 0.05$) for the 3 tested conditions: one-leg stance with eyes-closed on firm surface, eyes-open and eyes-closed on a balance pad conditions. Our results support a previous study that participants who were PA had better one-leg standing balance performance than the SB group did[10].

Both the previous and current studies displayed that participants in the PA group could maintain longer one-leg standing postural control on a firm surface with eyes open than the SB group did. However, neither the Balogun et al. results (mean ± SD = 187.3 ± 83.5 in the PA and 173.3 ± 79.3 seconds in SB groups) nor ours (mean ± SD = 122.1 ± 40.3 in the PA and 105.3 ±

42.3 seconds in SB groups) find significant difference between the two groups. The non-significant difference in our study could be attributed to a low power of test at 0.46 (effective size = 0.41). Another reason that the asymptomatic adolescents in both groups show no differences in their postural control during standing on firm surface with eye open although they had different levels of physical activity could be the wide range of physical activity level in the PA group. Furthermore, standing on one leg with eyes open is a typical test in which participants still obtain information from visual, somatosensory and vestibular systems without external disturbance. The completely information from visual, somatosensory and vestibular system leading to well integration process between sensory and motor system at high brain level. According to this result, we assumed that standing on one leg on a firm surface with eyes open may not be a sensitive postural balance test for asymptomatic adolescents, or it cannot differentiate balance performance among those who had different levels of physical activity. However, we suggested that one-leg standing with eyes open can be a baseline trial comparing with the eyes-closed conditions or when standing balance was tested on a balance pad.

The ability to maintain good control of the body in an upright position relies on the interaction of multiple processes among the sensory system, motor system and other processing systems[1719]. To maintain one-leg postural stability, sensory inputs from accurate external spatial orientation references are provided by the visual, vestibular and somatosensory systems. This sensory information is processed by the central nervous system to generate adequate muscle response, especially of the trunk and control of the lower extremities[20]. When visual information is removed during one-leg standing on a firm surface with eyes closed, participants maintain postural control based on somatosensory and vestibular information, so participants can definitely stand on one leg for a shorter time compared with the eyes-open condition. Moreover, the eyes-closed condition can possibly reflect lower limb muscle strength of the weight-bearing limb. Our findings for a one-leg stance with eyes closed on a firm surface (mean ± SD = 26.9 ± 18.6 seconds in PA and 18.1 ± 12.3 seconds in SB groups) are in accordance with previous studies[10-12]. Balogun and colleagues evaluated unipedal standing on a firm surface with eyes closed in 80 participants who were physically active and 120 sedentary adolescents and young adults with age ranging from 12 to 40 years. The results found longer mean ± SD of time = 113.4 ± 43.4 seconds in the physically active group than in the sedentary group (93.5 ± 39.7 seconds) [10]. Participants with a physically active lifestyle were assumed to have greater lower limb muscle strength, resulting in better balance performance than those with a sedentary lifestyle.

Furthermore, Hahn and co-workers evaluated one-leg standing balance on a stable surface with eyes closed in 339 athlete participants aged from 14 to 24 years. They displayed mean ± SD time of maintaining a standing posture for the participants aged 14 – 15 years at 30.6 ± 2.42 in male and 25.1 ± 2.35 in female[12]. Emery et al. also showed mean time (95%CI) of one-leg standing on a firm surface with eyes closed in 111 healthy adolescents aged 14 to 19 years at 25.43 (22.06 – 29.31)[11]. Most participants (70.37%)

in the current study were female and our results in the PA group (mean ± SD = 26.86 ± 18.61 seconds) were similar to previous findings of Hahn et al. and Emery et al. Comparing within the same age range, performance of the participants in our study displayed more variation of time on one-leg standing indicated by the large SD value. Male participants who were athletic in the Hahn et al. study had slightly better one-leg standing balance than those who were mostly female and not athletic in our study. The previous study suggested that athletes are better at standing balance performance.

All of the participants in the Hahn et al. study are athletic persons from two sports clubs, while the participants in the PA group of our study included both participants with and without sports practice. Our data shows a wide standard deviation of level of physical activity in the PA group range from 600 to 20,000 MET minutes per week, which confirmed the variation of physical activity in the PA. Participants in the PA group had various types of physical activity, such as exercise that involved standing, jumping, running, walking, or sports. We found that participants who had a MET score of nearly 20,000 minutes per week showed longer duration of sport, walking and exercise that involve jumping and running. Nevertheless, when we analyzed the power of the test, we found acceptable power for one-leg standing with eyes closed on firm surface condition at 0.72 (effect size = 0.55). Moreover, we also found significant relationships between times for performing one-leg standing on firm surface with eyes closed and the value of physical activity reported in the form of MET minutes per week of all participants as 0.37 (*p-value* = 0.001). The correlation could reflect that the questionnaire used in our study revealed useful information associated with the objective single-leg balance test.

Being tested at one-leg standing on a foam surface with eyes open altered information through the somatosensory and vestibular systems, resulting in increased postural sway, although they still gathered information from the visual system. Participants in the PA group of our study (mean ± SD = 48.74 ± 33.32 seconds) displayed similar results to those of Emery et al. (mean (95% CI) = 54.4 (47.3 – 62.61)[11]. However, overall results of Emery et al. showed slightly better performance than our study. This may be from the age of participants in their study (16.59 years) compared with those in our study (14.57 ± 1.39 years). This discrepancy can be explained by the development of postural stability which continues throughout the teenage period after 9-12 years of age[21, 22] and may extend to 15 years in some adolescents before that balance ability shows adult-like maturation[19, 23]. Balogun et al. suggested that the ability to maintain balance on one leg with eyes open and eyes closed improved with age[10]. McKay et al. also suggested that the functional postural control performance increased through childhood and adolescence and then reached a plateau during adulthood[8]. Adolescents in the PA group showed significantly longer one-leg standing in this condition compared with the SB group, with a high power of test at 0.98 (effect size = 0.86). Furthermore, the one-leg standing on a foam surface with eyes open showed the highest relationship at 0.42 (*p-value* = 0.001) with the value of physical activity among other conditions. These results imply that the one-leg standing balance test on a foam surface with eyes open could be a useful test to assess balance performance in adolescents who have different levels of physical activity.

Finally, the test becomes hardest when participants perform one-leg standing on a foam surface with eyes closed. This test condition alters somatosensory and vestibular feedback from the unstable supporting surface and cuts off the visual information while maintaining postural control. Children and adolescents mainly need information from the visual system to control their posture, perceiving information from somatosensory and vestibular systems only makes standing on one leg difficult, so they can maintain balance in this posture for a shorter time compared with the eyes-open condition. Our results show that the PA group had a significantly longer time than the SB group and the mean ± SD = 5.01 ± 2.28 seconds in the PA group was similar to that of Emery and colleagues (mean (95% CI) = 5.32 (4.98 – 5.68))[11]. Our results also showed an acceptable power of test at 0.81 (effect size = 0.62) and significant relationships between times performing one-leg standing on a foam surface with eyes closed and the value of physical activity reported in the form of MET minutes per week as 0.21 (*p-value* = 0.043). With sub-group analysis, we also compared postural stability of the one-leg stance in those with physical inactivity and those who had vigorous level of physical activity. Participants in the Vig group, who had more than 5 days of any combination of walking, moderate intensity activities or achieving at least 3000 MET minutes per week[15] showed significantly longer time of unipedal standing in all conditions than the PI group. These positive results confirm that standing on one leg could be a challenging test for postural stability in asymptomatic adolescents. Further studies should measure the lower limb muscles strength to confirm that adolescents who perform vigorous physical activity have their better postural stability due to their muscle strength.

Apart from positive results, our study contains several limitations. Firstly, the recruited participants were mostly young female adolescents. Therefore, the generalization of these results should be made with caution, since age and gender could be factors affecting postural control performance during one-leg standing. Secondly, the orders of one-leg standing postural control testing were not randomized. Therefore, muscle learning or fatigue might affect postural control performance during the test. Thirdly, the lower extremities muscle strength was not measured in the study, so we cannot conclude that both PA and SB groups had different lower extremities muscle strength. Finally, the single leg stance on the firm surface with eye open could be a suitable test for a baseline data and may not be able to differentiate the postural stability of asymptomatic adolescents due to various factors contributing to postural stability in adolescents and their physical condition is not deteriorate like elderly. The main and sub-group results support the importance of keeping more than moderate level of physically active in adolescence in order to control ones postural stability better.

CONCLUSION

In conclusion, participants who are physically active especially those with vigorous physical activity perform significantly better at postural stability measured by a single-leg stance than those in the sedentary group. The one-leg standing on a balance pad with eyes open seems to be a challenging task and is appropriate for a balance test in asymptomatic adolescents.

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