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Original Article

Ipsilateral versus contralateral static endurance- balance abilities among healthy college students

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الملخص

أهداف البحث: سعت هذه الدراسه ألي تحديد الأرتباط والفرق، إن وجد، بين الجانب المماثل وبين الجانبين المتقابلين أثناء تمرين التوازن والتحمل الثابت.

طرق البحث: شارك ١١٢ طالب جامعي يتمتع بصحه جيده (٥٥ إناث، ٥٧ ذكور) في هذه الدراسه. أجري كل مشارك تمرين Quadruped bird dog (رفع ذراع واحده والساق في الجانب المقابل) والحفاظ علي التوازن في حاله ثابته. كما أجري كل مشارك تمرين ال side bridge من وضع الأستلقاء علي الجانب ورفع الجذع والوركين والحفاظ علي التوازن لأطول فتره ممكنه.

النتائج: أظهر أختبار Wilcoxon فرق ذو دلاله أحصائيه لتمرين Quad-ruped bird dog وليس لتمرين Side bridge. كما أظهرت الدراسه معامل أرتباط قوي مقداره 0.85 و 0.75 لتمرين Quadruped bird dog وتمرين Side bridge علي التوالي.

الأستنتاجات: قد تكون هذه النتائج مفيده لأخصائي التأهيل للتقييم الموضوعي لقدرات التوازن والتحمل الثابت ومتابعة التقدم في العلاج. كما أنه يساعد في تحديد التمرين المناسب والمتدرج لثبات الجذع.

الكلمات المفتاحيه: الميكانيكا الحيويه؛ الأستقرار الأساسي؛ التوازن الوضعي؛ التحمل الساكن؛ شاب بالغ

Abstract

Objectives: This study sought to determine the association and the difference, if any, between the levels of the contralateral and between the levels of the ipsilateral sides during static endurance-balance exercise.

Methods: One hundred twelve healthy active- college students (55 females and 57 males) participated in this cross-sectional study. Each participant performed the contralateral (raising one arm and opposite-side leg) quadruped bird dog exercise and balanced in static condition. Side bridge exercise was performed from lying on your side then engaging your core muscles and lifting your upper body and hips off the ground, maintaining a straight line and holding this position as long as tolerated.

Results: Wilcoxon signed rank test showed significant difference ($p = 0.004$) between the contralateral right and left quadruped bird dog but insignificant difference ($p = 0.059$) between the ipsilateral right and left side bridge endurance-balance exercises. Mann–Whitney *U* test showed that the holding time was significant across gender for the contralateral but was insignificant for the ipsilateral endurance-balance exercise. Mann–Whitney *U* test was insignificant ($p > 0.05$) between those being recreationally active or inactive. Kruskal–Wallis test revealed insignificant difference between body mass index categories. Spearman's *rho* correlation coefficient showed strong positive correlation equals 0.85 and 0.75 ($p < 0.001$) of the contralateral quadruped bird dog and the ipsilateral side bridge exercises respectively.

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Conclusions: A significant difference was observed for contralateral, while no significant difference was found for ipsilateral endurance-balance abilities. Therefore, clinicians and rehab specialist should consider these findings when assessing the endurance-balance abilities to properly devise appropriate exercise progression of different trunk stabilizers.

Keywords: Biomechanics; Core stability; Postural balance; Static endurance; Young adult

Introduction

The endurance-balance abilities are essential to improve motor control of trunk muscles. It is often used as a measure of core strength, stability, and muscular endurance.[1–4] Quadruped bird dog (QBD) and side bridge exercises are popular core exercises commonly used for the prevention and treatment of spine disorders and improvement of athletic performance.[5–8] This type of exercise typically focuses on engaging and strengthening core muscles for improved stability and endurance.[8,9] Exercises are easy and convenient, activate the trunk stability muscles, and are effectively used in clinical settings. Clinical data suggest that individuals with core muscles weakness and instability exhibit impaired ability to perform both the QBD exercise and the side bridge exercise.[3,9] To perform the QBD exercise, every participant has to assume the 4-point kneeling position and raise one arm and opposite-side leg and balance as long as tolerated while the side bridge requires lying on the side with elbow directly under shoulder then lift hips off the ground and balance.[5,9] Clinicians have also devised different variations of the core exercises using biomechanical features to render the exercises more challenging and to produce higher levels of muscle activation.[5,6,10]

Static endurance-balance holding time is defined as the duration for which an individual can maintain a balanced, static position without experiencing fatigue or loss of stability. The duration of static holding time can vary depending on the individual's fitness level, strength, and overall endurance. It is clear the time decreases when there is deconditioning, suggesting that endurance is impaired. Deconditioning and poor physical capacity are prevalent among physical therapy college students who need adequate physical capacity to meet the physical demand of their job.[11,12] However, the average of length of time of holding and balance during hand-knee and side bridge positions among healthy college students is undetermined. The symmetry or asymmetry (right versus left side) of endurance-balance abilities among healthy college students is also unknown. There was gap in the body of knowledge regarding the association and the difference, if any, between right and left ipsilateral and between contralateral sides for static endurance-balance abilities among healthy college students. Moreover, unlike other laboratory studies that needs specific high-tech equipment and special training, QBD and side bridge exercises were practically analyzed using stopwatch to determine the length of time of holding on at that given position and maintaining balance.

The first aim of the study was to determine the strength of association and the difference, if any, of the static endurance-balance abilities between the contralateral sides of the body during QBD exercises. Thus, we hypothesized that there is no statistical difference between the contralateral sides during QBD exercises among healthy college students. The second aim of the study was to determine the strength of association and the difference, if any, between the ipsilateral sides of the body during side bridge exercises. We hypothesized that there is no statistical difference between the ipsilateral sides during side bridge exercises.

Materials and Methods

Study design

The present study was an observational cross-sectional study conducted between October 2022 and April 2023. Informed consent was obtained from every participant after explaining the steps of the study protocol. The study was approved by the research ethics committee (CMR-PT-2022-06) of College of Medical Rehabilitation Sciences at Taibah University (CMRS-TU) and conducted in accordance with the declaration of Helsinki. The sample size was calculated using G* power (version 3; University of Kiel, Germany). Calculations were based on power (1−β error probability) of 0.8, effect size of 0.5 and α error of 0.05 for a priori power analysis. The statistical test used the means of Wilcoxon−Mann−Whitney test of the *t* test family.[13]

Participants

One hundred twelve participants (55 females and 57 males) volunteered to participate in this study. All participants from (CMRS-TU), KSA were consecutively recruited using sample of convenience. Healthy college students, who are willing to participate, were included in the study. Students were excluded if anyone suffers from obesity, significant mobility limitation, could not perform the testing exercise, had a history of spine surgery, sustained recent injury with having pain intensity more than 3 out of 10 or suffers from balance disorder.

Procedure

The principal researcher provided full training to group of physical therapy investigators and examined them before being involved in the actual data collection. Investigators were responsible for screening individuals for eligibility to be included. Investigators used a data collection form to systematically collect all information and outcome measurements data. The investigators explained the protocol of measurements to every participant, and after giving consent to participate, all data collected were kept in strict confidence. Recreational status was determined by asking every participant to indicate his/her physical activity level. Participants were classified as recreationally active if being

involved in moderate intensity activity for 30 min for 5 times/week or vigorous intensity exercise for 3 times/week.[14,15] All measurements were conducted at CMRS-TU.

Spinal mobility[16,17]

Forward sagittal spinal mobility was assessed by instructing every participant to stand up straight and bend forward as far as possible. If the participant managed to touch the floor even with fingertip, a zero distance was given. Backward spinal mobility was assessed by having the participant to lie down on stomach and to push up as far as possible. The investigator measured the perpendicular distance from the sternal notch to the surface. Side bending mobility was assessed by instructing every participant to stand up bare feet and then slide his hand right hand, for example, down the lateral side of his right leg as far as possible. The formula (x_1-x_2/x_1) was used to calculate side bending mobility where x_1 is the distance from fingertip to the floor before bending and x_2 is the distance after side bending.

Quadruped bird dog exercise

The QBD exercise is a core-strengthening exercise that targets the muscles in your back, abdominals, shoulders, arms, hips, quads, hamstring and glutes.[5,6,8] Each participant performed the contralateral (raising one arm and opposite-side leg) QBD exercise and held in static condition. Every participant was given the chance to engage and practice familiarization trials before having the actual measurement. The individual assumed the 4-point kneeling position with having hands directly under shoulders and knees directly under hips and balance. Every individual then smoothly lifted one arm straight out to the front while simultaneously extended the opposite leg straight back, keeping them parallel to the floor and hold at that position. Right after, every participant returned to the starting position, took 1 min rest then repeated on the other side with the opposite arm and leg.[5,18] The investigator encouraged every participant to keep the spine in neutral position, engage core muscles and breathe normally. The investigator has counterbalanced the order of measurements. The operational definition of right bird dog is the exercise when the individual extends the right arm and left leg and balance as long as tolerated (Figure 1a), while the left bird dog is the exactly opposite exercise in which the individual extends the left arm and right leg (Figure 1b).

Side bridge exercise[5,9]

The side bridge exercise, also known as the side plank, is a core-strengthening exercise that mainly targets the muscles on the side of your body. It helps improve core stability, balance, and overall strength in the abdominal area. Every participant practiced a familiarization trial before having the actual measurement. Start by lying on your side with your elbow directly under your shoulder while resting on your forearm. Keep your legs straight and stack your feet on top of each other or stagger them for better balance. Engage your core muscles and lift your upper body and hips off the ground, maintaining a straight line from your head to your feet. Hold this position if tolerated and breathe normally (Fig. 1c and d). The investigator gave encouragement to individuals to hold if tolerated and then slowly lower his/her hips back down and take 1 min rest. The investigator counterbalanced the order of measurements.

Statistical analysis[19]

Test of normality of data distribution was conducted using Shapiro–Wilk test. Levene's test was used to establish equality of variances. Participants' descriptive data for all study variables was reported as mean ± SD, median and interquartile range, frequency of occurrence and percentage. A non-parametric related samples Wilcoxon test was run to examine the difference within endurance-balance holding time of both ipsilateral right and left side and to examine the difference within contralateral right and left side. Mann–Whitney *U* test was used to examine the difference between endurance-balance holding time of the right and left sides across categories of gender as well as across categories of recreational status. Kruskal–Wallis test was run to examine the difference between endurance-balance holding time of the right and left sides across categories of body mass index. Spearman's *rho* was conducted to determine the degree of agreement of endurance-balance abilities between the levels of QBD exercise and the levels of the side bridge exercise. Statistical significance was set at alpha ≤ 0.05. IBM- SPSS 23 (IBM Corp. Armonk, NY, USA) was the software used for all data analyses.

Results

Quantitative and qualitative descriptive statistics and socio-demographic characteristics of study participants are included (Table 1). Normality of data distribution was not established. Wilcoxon signed rank test examined the contralateral right and left QBD endurance-balance exercises. A significant difference was found in the results ($p = 0.004$). Wilcoxon signed rank test examined the ipsilateral right and left side bridge endurance-balance outcome. No significant difference was found in the results ($p = 0.059$) (Table 2). Mann–Whitney *U* test showed that the endurance-balance holding time of the contralateral right and left sides of the QBD exercise was not the same across categories of gender (Figure 2). The endurance-balance holding time of the ipsilateral side bridge exercise was the same across categories of gender (Table 2). Mann–Whitney *U* test did not show any significant difference in the endurance-balance holding time of those being recreationally active or inactive during performing the contralateral or the ipsilateral side bridge exercise. Kruskal–Wallis test was conducted comparing the endurance-balance holding time across categories of body mass index (BMI). No significant difference was found ($p > 0.05$), indicating that being

a. Right bird dog b. Left bird dog

c. Right side bridge d. Left side bridge

Figure 1: Contralateral right and left bird dog exercise and the ipsilateral right and left side bridge exercise.

underweight, normal or overweight did not seem to influence the holding time of the QBD exercise or the side bridge exercise.

Table 1: Participants' socio-demographic characteristics (N = 112).

Quantitative variables	Mean	±SD	Range (Minimum−Maximum)
Age	20.98	1.07	(19−23)
Weight "kg"	60.69	13.61	(37−90)
Height "m"	1.64	0.09	(1.47−1.84)
BMI	22.21	3.67	(15.80−29.77)
Spinal mobility			
Forward bending	6.11	8.52	(00−32)
Backward bending	33.81	6.85	(18−48)
Right side bending	0.29	0.07	(0.15−0.42)
Left side bending	0.29	0.07	(0.13−0.44)
Qualitative variables	**Number**		**Percentages %**
Gender			
Females	55		49.1 %
Males	57		50.9 %
BMI			
Underweight	14		12.5 %
Normal	75		67.0 %
Overweight	23		20.5 %
Pain status			
Pain free	83		74.1 %
Pain symptoms	29		25.9 %
Recreational status			
Active	57		50.9 %
Inactive	55		49.1 %

Table 2: Wilcoxon test and Mann−Whitney *U* test of the study outcome variables.

Outcome parameter	Median (IQR)	Wilcoxon test *p-value*	Gender	Mann−Whitney *U* test *p-value*
Quadruped bird dog-Rt	49.50 (31.25−81.50)	$P = 0.004$*	Males Females	$P = 0.02$*
Quadruped bird dog-Lt	47.35 (28.40−74.75)		Males Females	$P = 0.04$*
Side bridge- Rt	37.70 (25.77−58.75)	$P = 0.059$	Males Females	$P = 0.14$
Side bridge- Lt	38.00 (26.00−55.50)		Males Females	$P = 0.67$

IQR: interquartile range; *P*: probability; *: significance

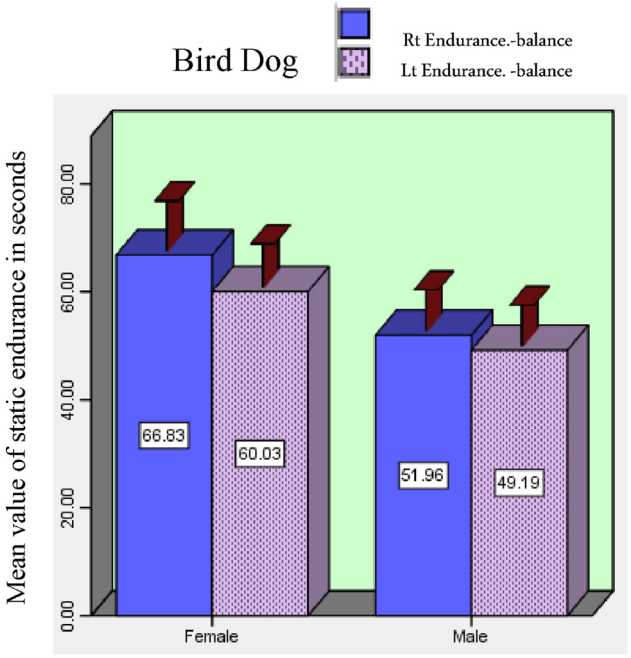

Figure 2: Bar chart showing the difference between females and males static endurance balance.

Spearman's *rho* correlation coefficient was calculated for the relationship between participants' holding time of right and left sides. A strong positive correlation was found $rho_{110} = 0.85$, $p < 0.001$ indicating a significant relationship between the two levels of the QBD exercise. A strong positive correlation was also found $rho_{110} = 0.75$, $p < 0.001$ indicating a significant relationship between the two levels of the side bridge exercise.

Discussion

The main findings of the study showed decreased static endurance-balance holding time among active college students. There was also imbalance with respect to the holding time of the contralateral sides of the body but not for the ipsilateral sides of the body. The results of the study agree

with the study conducted by El-gohary et al.[9] who compared the static endurance-balance ability of the ipsilateral right and left sides when doing side bridge static endurance. Results showed positive correlation with $r_{(110)} = 0.89$ and insignificant difference between the two sides of the body, more specifically, in the males group.

El-gohary et al.[9] findings are in agreement with the findings of the current study regarding the strength of the positive correlation of the endurance balance of both sides of the body. There was also insignificant difference between both sides of the body in the two studies. The findings are clinically expected since the participants in both studies were healthy college students. However, the average values of the static endurance-balance seemed to be subpar and fell short of expectations considering the participants age of 20.9 ± 1.06 and the physical demand needed to meet daily life and job physical challenges. It is necessary to acknowledge that in El-gohary et al.[9] study, the sample was only male participants and the side bridge static endurance-balance reflects ability of the ipsilateral side of the body while in the current study the sample size was bigger and included both males and females and thoroughly assessed the static endurance-balance ability of ipsilateral and contralateral sides of the body. Modification of the base of support, via limb movement, produces substantial variation of muscle activation.[20,21] García-Vaquero et al.[20] found that single leg support during side bridge exercises increase rotational torques and creates higher level of trunk muscles activation. Okubo et al.[5] reported that the side bridge exercises with support on the right elbow and foot showed the greatest side-to-side asymmetry in the level of activation of lumbar and spinal musculature.

Regarding the contralateral sides of the body, results of the current study showed significant difference in the static endurance-balance holding time. The findings agree with the findings reported by Okubo et al.[5] who analyzed muscle activity on sample of healthy men using side bridge, hand-knee and other exercises. Results showed significant variation and asymmetrical level of activation between right and left side. This finding is in harmony with the data by Allison et al.[22] specifically examined laterality and directional specificity of feedforward response of deep abdominals in responses to rapid arm raising exercises. Investigators found that the deep trunk muscles revealed different control mechanisms and significant difference between sides. Investigators concluded that the feedforward and muscle activity is asymmetric between sides and is specific to the direction of arm movement. Okubo et al.[5] reported that exercises performed from the hand-knee position showed a greater activity of the abdominal muscles. Stanton and Kawchuk[23] pointed out that cocontraction of abdominal muscles increases postero-anterior spinal stiffness. Therefore, the hand-knee bird dog exercise with contralateral arm and leg lift creates asymmetry in base of support with subsequent variation and asymmetry in the level of activation of different muscles.

García-Vaquero et al.[20] found that QBD exercise primarily produce the greatest activity of the erector spinae on the side of the elevated leg and of the internal oblique on the side of the elevated arm. The limb raise increases rotational torques and creates higher level of trunk muscles activation. The biomechanical challenges of reducing base of support facilitate the co-activation of trunk muscles which improve trunk stability.

Barati et al.[2] reported positive correlation and significant relationship between trunk muscles endurance and static balance. They studied a sample of 50- male college students while the current study was conducted on a sample of 112 college student including both males (50.9 %) and females (49.1 %). That might explain the difference in the median value of 30 s in their study compared to the current study median value of 37.7 and 38.00 for right and left side bridge lateral endurance respectively. Lee and McGill[24] revealed that both static and dynamic approaches are essential in any core training protocol to enhance performance.

Conclusions

The findings of the study indicate a significant difference in the contralateral static endurance-balance abilities among healthy students during quadruped bird dog exercises. The findings are useful to guide rehab specialist to objectively assessing the endurance-balance abilities and then determining the appropriate exercise progression of different trunk stabilizers. Further research is recommended to explore the implications of these findings among patients.

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

No conflicts of interest to report.

Ethical approval

The study was approved by ethical research committee of College of Medical Rehabilitation Sciences, Taibah University (CMR-PT-2022-06). The study was operated according to the Saudi regulations of the national bioethics committee and the guidelines of the declaration of Helsinki.

Authors' contributions

TME, AMA and MMA conceived and designed the study. TME, YSA and MMA conducted data collection. TME and AMA analyzed and interpreted data. TME, YSA and MMA wrote the final draft. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript. TME sent the paper for publication.

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Authorship

This work is original, has not been published or under consideration elsewhere.

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