

Trunk Extensor, Flexor and Lateral Flexor Endurance Time in Sedentary Workers Aged 20-49 Years

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Objective: The purposes of this study were to 1) quantify trunk endurance times according to subjects' age and sex; and 2) identify factors affecting the endurance times.

Materials and Method: Endurance times of sedentary workers aged 20-49 years were determined by an extensor endurance, a flexor endurance, and right and left side bridge (trunk lateral flexor) tests. Each test was performed once in random order with a resting period of 10 minutes between tests.

Results: Of 137 workers, Two-way analysis of variance indicated that age had no effect on these 4 isometric trunk endurance tests. Sex had an effect on the extensor endurance test, and right and left side bridge tests. Females had longer endurance times than males for the trunk extensor muscle, whereas males had longer endurance times than females for right and left lateral flexor trunk muscles. Low negative but significant Pearson's correlations ($r = -0.233$ to -0.377 , $p = 0.047$ to 0.001) were found between extensor endurance times vs. body weight and abdominal skinfold thickness in both sexes. Only in males, both right and left side bridge endurance times correlated with abdominal skinfold thickness ($r = -0.296$ and $r = -0.382$, respectively, $p < 0.05$ both).

Conclusion: Sex, weight and abdominal skinfold thickness factors should be considered when trunk muscle endurance is evaluated.

Keywords: Trunk muscle endurance, Age, Sex, Weight, Skinfold thickness

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Low extensor muscle endurance is one of the predictors of low back pain. Biering-Sorensen in 1984⁽¹⁾ found that high isometric endurance of back muscles may prevent first-time occurrence of low back trouble in men. Other studies clearly demonstrated that the prevalence of low back pain was high in groups with a low static endurance capacity of the trunk^(2,3).

In addition to extensor endurance or Sorensen test, which has been widely studied, McGill and co-workers proposed flexor and lateral flexor endurance tests^(4,5). These tests were adapted from trunk exercises usually used by therapists for treating low back pain patients. The normative database of these four endurance tests in both sexes with a mean age of 23

years was reported by the same investigators. Factors (such as age, sex and anthropometric variables) affecting these flexor and lateral flexor trunk muscle endurance tests have not been studied, unlike extensor endurance time, which has been intensively investigated^(1,3,6-8). The purposes of this study were to 1) quantify trunk extensor, flexor, right and left lateral flexor (side bridge) endurance times according to subjects' age and sex and 2) determine the correlation between age, sex, weight, abdominal skinfold and endurance times.

Material and Method

Subjects

Sixty-four male and 73 female volunteers within the age range of 20-49 years old were recruited from many offices within and near Siriraj Hospital, Bangkok, Thailand. Subjects were recruited according to their sex and age groups of 20-29, 30-39 and 40-49. These categories usually comprise physical fitness normative data⁽⁹⁾. No subjects had a history of low back pain, which required having had treatment within

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1 year prior to the time of study. All subjects were sedentary who had physical activity level scores of less than 23 according to the National Heart Foundation of Australian questionnaire⁽¹⁰⁾ and body mass index less than 25.5 kg/m². The suprailiac skin fold was measured by venier calipers (Accurex-Measure, USA). Female subjects who had menstruation and were pregnant at the time of the study were excluded. A pilot study was conducted in a smaller group (n = 20) to determine reliability of the trunk endurance tests and sample size. The test-retest reliability of trunk extensor, flexor, right and left side bridge tests were 0.923, 0.806, 0.791 and 0.869, respectively⁽¹¹⁾. This study was approved by the Ethics Committee on Research involving Human Subjects, Faculty of Medicine Siriraj Hospital, Mahidol University (SiIRB COA NO. Si 5/ 2003).

Procedure

After stretching trunk muscles, the subjects performed each endurance test for familiarization. Starting positions of all endurance tests were assumed according to McGill⁽⁴⁾ except that both side bridge tests were modified by supporting the upper part of the body by a 40x75x20 cm-firmed pillow instead of using the subject's lower arm. A feedback pad was placed on the skin over 1) the upper back between the scapulars (extensor endurance test), 2) the sternum (flexor endurance test) 3) the right or 4) the left greater trochanter (side bridge test) to maintain trunk position and monitor by a researcher (KS) during each isometric trunk endurance test. Endurance times were recorded by a stopwatch (Casio HS3, Japan). The test ended when 1) subjects could not hold the posture (ended the test by themselves) or 2) they stopped touching the feedback pad. All tests were performed only one time in random order with a 10-minute rest between each test⁽¹¹⁾.

Data analysis

The two-way analysis of variance (ANOVA) was used to test the effects of sex and age group on trunk endurance time. Unpaired t-test was also used to test the differences of all trunk endurance times between females and males. The Mann-Whitney test was used in cases of non-normal distribution of data. Pearson's correlation coefficients and Spearman's rank correlation test were used to determine correlation among endurance times and subject characteristics. The statistical significance was set at *p*-value level less than 0.05

Results

Characteristics of the subjects categorized by sex and age are shown in Table 1. The results from the two-way ANOVA showed that only sex had effects on all four endurance times ($F = 40.726$ to 0.506 and $p = 0.6$ to -0.001) and no effects of age were found on endurance times ($F = 0.627$ to 2.197 and $p > 0.05$). All age groups (20-39, 30-39 and 40-49 years of age) for each sex data were then combined.

Means and standard deviations of extensor, flexor, right side bridge and left side bridge endurance times were revealed according to sex (Table 1). Ratios of endurance times were calculated and averaged according to McGill⁽¹²⁾. The ratios of flexor endurance, right side bridge and left side bridge, endurance times versus extensor endurance times in males were 0.87, 0.65, and 0.64, respectively. In females, the ratios of flexor endurance, right side bridge and left side bridge endurance times versus extensor endurance time were 0.74, 0.48, and 0.46, respectively.

Unpaired t-tests were used to compare endurance times between males and females. It was found that female extensor endurance time was significantly longer than that of males (114.9 ± 32.6 versus 103.02 ± 7.8 seconds, $p < 0.05$), whereas males' right and left side bridge endurance times were significantly longer than that of females (64.8 ± 13.0 versus 51.5 ± 11.7 seconds for right side bridge and 63.4 ± 13.8 versus 48.9 ± 9.7 seconds for left side bridge, $p < 0.001$). Mann-Whitney test found no significant difference of trunk flexor, endurance time between males and females.

Correlation among the four endurance times, weight, height and abdominal skinfold thickness in each sex were analyzed (Table 2). For males, it was found that extensor endurance time had a significant negative relationship with weight and abdominal skinfold thickness ($r = -0.354$ and $r = -0.364$, $p < 0.05$, respectively). No correlations were found among the remaining three endurance times with weight, height or abdominal skinfold thickness. In addition, both right and left side bridge endurance times had a negative relationship with abdominal skinfold thickness ($r = -0.296$ and $r = -0.382$, $p < 0.05$, respectively). The results from females were similar to that of males. For female subjects, extensor endurance time had a negative relationship with weight and abdominal skinfold thickness ($r = -0.233$ and -0.377 , $p < 0.05$, respectively). Furthermore, for the correlation among the four endurance times in females, extensor endurance time had low correlations with flexion and right side bridge endurance times ($r = 0.388$ ($p < 0.001$) and 0.276 ($p < 0.01$), respectively, (Table 3). Flexor

endurance time also had low correlations with right and left side bridge endurance time ($r = 0.310$ and $r = 0.341$, $p < 0.01$, respectively). Right and left side bridge test had a significantly moderate correlation ($r = 0.686$, $p < 0.001$). No significant correlation was found between extensor and left side bridge, endurance time. For females, a significantly low correlation was found between extensor and flexor endurance times ($r = 0.288$, $p < 0.05$). In addition, extensor endurance time had moderate correlations with right and left side bridge endurance times ($r = 0.553$ and $r = 0.0546$, $p < 0.001$, respectively). Significantly, high correlation between right and left side bridge endurance times ($r = 0.856$, $p < 0.001$) was also found (Table 3).

Discussion

This study was the first to investigate four sides of trunk endurance tests in both sexes and various age groups. Many studies have investigated extensor

endurance time, and their values were far longer than this current study^(1,7,13,14). This might be due to racial differences. Up to now, there have been no publications of these endurance times among other ethnics, e.g., Asian or Latino, except Caucasian, which can be used to compare with the results of this study. For flexor endurance time, unfortunately, only one study of McGill et al⁽⁴⁾ could be used to compare. However, the values of flexor endurance time, and also side, side bridge tests from the current study were shorter than those of McGill's study. Racial factors and the different starting positions of the test could also explain these differences. Instead of using the arm to support the body, this current study used a firm pillow. This modification from McGill's protocol was the result from our pilot study. Most subjects, especially females, complained of pain and fatigue in the supporting arm. To avoid this phenomenon, the current study used a pillow to support the upper body on the lateral side of

Table 1. Characteristics of subjects; mean \pm SD (n = 137)

Demographic characteristic	20-29 years		30-39 years		40-49 years		All	
	Male (n = 21)	Female (n = 25)	Male (n = 23)	Female (n = 25)	Male (n = 20)	Female (n = 23)	Male (n = 64)	Female (n = 73)
Age (year)	25.5 \pm 2.8	25.1 \pm 2.4	34.8 \pm 3.5	34.4 \pm 3.2	42.6 \pm 2.4	43.5 \pm 2.8	34.2 \pm 7.5	34.0 \pm 8.0
Weight (kg)	58.6 \pm 8.5	49.4 \pm 6.0	61.5 \pm 8.6	49.4 \pm 7.0	65.2 \pm 7.1	52.8 \pm 6.4	61.7 \pm 8.4	50.5 \pm 6.6
Height (cm)	166.7 \pm 5.6	157.7 \pm 4.2	166.4 \pm 4.6	155.5 \pm 4.1	168.0 \pm 5.2	155.0 \pm 3.5	167.0 \pm 5.1	156.1 \pm 4.1
BMI (kg/m ²)	21.1 \pm 2.4	19.9 \pm 2.5	22.2 \pm 2.6	20.4 \pm 2.5	23.0 \pm 2.0	21.9 \pm 2.0	22.1 \pm 2.5	20.7 \pm 2.5
Physical activity level score	17.5 \pm 2.4	16.6 \pm 3.8	18.7 \pm 3.1	17.7 \pm 2.6	17.9 \pm 4.0	18.1 \pm 2.8	18.0 \pm 3.2	17.5 \pm 3.0
Suprailiac skin fold (mm)	9.5 \pm 6.1	11.2 \pm 4.5	14.5 \pm 7.8	12.0 \pm 4.9	18.2 \pm 6.8	15.0 \pm 5.6	14.0 \pm 7.5	12.6 \pm 5.2

Table 2. Means, standard deviations and ratios (endurance time/extensor endurance time) of extensor, flexor, right side bridge and left side bridge endurance times

Trunk Endurance Test	Endurance Times (seconds)				p-values
	Male (n = 64)		Female (n = 73)		
	Mean \pm SD	Ratio	Mean \pm SD	Ratio	
Extensor	103.06 \pm 27.78	1.00	114.89 \pm 32.60	1.00	0.025*
Flexor	86.88 \pm 28.98	0.87	82.44 \pm 37.10	0.74	0.06 ^{ns}
Right side bridge	64.75 \pm 12.99	0.65	51.49 \pm 11.71	0.48	0.001*
Left side bridge	63.38 \pm 13.77	0.64	48.93 \pm 9.74	0.46	0.001*

* = Significant differences of endurance times between sexes from unpaired t-test

ns = Non-significant difference of endurance times between sexes from Mann-Whitney test

Table 3. Pearson's correlation coefficients (r) and p-values between extensor, flexor, right side bridge, and left side bridge endurance tests versus weight, height and skin fold thickness in male and female subjects

Endurance Test	Male (n = 64)						Female (n = 73)					
	Weight		Height		Skin fold thickness		Weight		Height		Skin fold thickness	
	r	p-value	r	p-value	r	p-value	r	p-value	r	p-value	r	p-value
Extensor	-0.354	0.004**	-0.213	0.091	-0.364	0.003**	-0.233	0.047*	0.219	0.063	-0.377	0.001**
Flexor	0.085 ^a	0.503	0.123 ^a	0.333	-0.037 ^a	0.773	-0.066 ^a	0.578	0.071 ^a	0.551	-0.029 ^a	0.806
Right side bridge	-0.121	0.343	-0.081	0.525	-0.296*	0.017	-0.222	0.059	-0.153	0.196	-0.217	0.065
Left side bridge	-0.224	0.076	-0.146	0.250	-0.382	0.002**	-0.164	0.165	-0.224	0.057	-0.125	0.290

* p-value < 0.05, ** p-value < 0.01

^a Tested by Spearman rank correlation test

the shoulder and upper arm. No complaints were reported from this modified starting position.

The effect of age on endurance times is still controversial. Numerous studies have shown that age has a negative correlation with endurance time^(1,15,16). In contrast, this study found no age effect on any endurance times in either sex. The difference can be explained by the differing age ranges among the studies. This study's age range of 20-49 years contrasted with that of the other studies including subjects over 50 years⁽¹⁷⁾. The wider and older age range may have created the negative correlation between age and endurance time reported in the previous studies.

Females had longer extensor endurance time than that of males in this study. The result is in accordance with previous studies^(4,7,13). The differences in muscle fiber distribution of slow twitch (ST) and fast twitch (FT) in males and females might explain this finding. It was shown that the lumbar muscles in females had a higher percentage of the slow twitch, muscle fiber area (72.8% for females and 66.4% for males) than males⁽¹⁸⁾. The greater oxidative capacity of the lumbar muscles, reflecting a longer time of sustained isometric contraction would create potential differences in females.

This present study revealed that males had longer endurance times of the right and left side bridge (lateral trunk endurance) than those of females. McGill et al also found similar results with no explanation⁽⁴⁾. Bigger hips in females, concentrating weight or resistance in the middle of the body would affect the lower endurance times of this test, whereas weight in males was distributed not only at the hip area but also all over the body. This might be the reason endurance times of lateral flexion of males was longer than those of females.

The significant negative correlation between extensor endurance time with weight and skinfold (percent body fat) are in accordance with the results by previous studies⁽⁶⁻⁸⁾. One selection criterion in this present study was a BMI < 25.5 m/kg². This meant overweight or high percent body fat subjects were excluded. The low correlation coefficient ratios (r < 0.4) from our results might have increased if overweight or obese subjects had been included. A negative correlation of right and left side bridge, endurance times with skinfold of male subjects was shown, whereas no correlation was demonstrated between weight and these lateral flexion endurance times. Regardless of body weight factor, the fatter the waist, the lower the lateral flexion endurance time was shown. Further

investigation in this issue is warranted.

McGill^(4,12) has developed trunk muscle endurance ratios by dividing any trunk endurance time by extensor endurance time to determine trunk muscle imbalance between extension-flexion, right-left trunk lateral flexion and to design therapeutic exercise for low back pain patients. However, correlation coefficients among endurance times in females in our present study were surprisingly low. A stronger correlation among these endurance times is expected among subjects with no low back pain. Unexpectedly, no correlation was found between extensor and left side bridge, endurance times in females. Clinical uses of these endurance ratios in females are still questionable. For males, the correlation coefficients among endurance times were higher than that of females. The endurance ratios in males can be used as guidelines for determining trunk muscle imbalances especially between the right and left side bridge, which has a high correlation coefficient ($r = 0.856$). Further work is needed to explore this issue.

Conclusion

Age has no effect on all trunk muscle endurance in the age range of 20-49 years. Females have longer extensor endurance time than males, whereas males have higher lateral flexion endurance. Weight and skinfold thickness have small to medium correlations with extensor endurance in both sexes. Right and left side bridge tests for lateral flexion endurance in males have small to medium correlations with skinfold thickness. Because of small correlation among trunk endurance times, especially in females, clinical use of trunk endurance ratios are still unclear.

What is already known on this topic?

Low back extensor endurance can predict future low back pain in male populations. Trunk flexor and lateral flexor endurance tests and ratios among the endurance times were proposed. However, the factors affecting these endurance times and their ratio against extensor endurance still need to be explored.

What this study adds?

Sex, weight and suprailiac, skin fold thickness affect extensor and side bridge endurance tests. Moderate correlations between trunk extensor endurance versus side bridge test were found in males, whereas they were quite low in females. The ratios among endurance times should be used with caution, especially in females.

Acknowledgement

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Potential conflicts of interest

None.

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ความทนทานของกล้ามเนื้อเหยียด-งอหลัง และกล้ามเนื้อเอียงตัวในคนทำงานนั่งโต๊ะที่มีอายุ ระหว่าง 20-49 ปี

วรรณะ ชลายนเดชะ, ศศิพร เกรียงเขียวชาญ

วัตถุประสงค์: 1) ทาค่าความทนทานของกล้ามเนื้อลำตัวโดยแบ่งตามอายุและเพศ 2) ทาบัจจัยที่มีผลต่อความทนทานของกล้ามเนื้อลำตัว

วัสดุและวิธีการ: ความทนทานของกล้ามเนื้อลำตัวในผู้ที่ทำงานนั่งโต๊ะอายุระหว่าง 20-49 ปี ถูกประเมินโดยการทดสอบจับเวลาความทนทานของกล้ามเนื้อเหยียดหลัง กล้ามเนื้อองคิ้ว และกล้ามเนื้อเอียงตัวทั้งสองข้าง ทำการประเมินด้วยการสุ่มที่ทดสอบและมีระยะพักแต่ละการทดสอบ 10 นาที

ผลการศึกษา: จากประเมินในกลุ่มตัวอย่าง 137 คนและวิเคราะห์ด้วย Two-way analysis of variance พบว่าอายุไม่มีผลต่อความทนทานของกล้ามเนื้อลำตัวทั้ง 4 แบบ พบว่าเพศมีผลต่อความทนทานของกล้ามเนื้อเหยียดหลังและกล้ามเนื้อเอียงตัวทั้งสองข้าง หญิงจะมีความทนทานของกล้ามเนื้อเหยียดลำตัวมากกว่าชาย ขณะที่ชายมีความทนทานของกล้ามเนื้อเอียงตัวมากกว่าหญิง ในทั้งหญิงและชาย ความทนทานของกล้ามเนื้อเหยียดหลังจะแปรผกผันกับน้ำหนักตัวและความหนาของชั้นไขมันใต้ผิวหนังบริเวณหน้าท้อง ($r = -0.233$ to -0.377 , $p = 0.047$ to 0.001) ความทนทานของกล้ามเนื้อเอียงตัวทั้งชาย-ขวา จะมีความสัมพันธ์กับความหนาของชั้นไขมันใต้ผิวหนังเฉพาะในผู้ชาย ($r = -0.296$ and $r = -0.382$ ตามลำดับ, $p < 0.05$ ทั้งสองข้าง)

สรุป: ควรคำนึงถึงปัจจัยของ เพศ น้ำหนัก และความหนาของชั้นไขมันหน้าท้องด้วย เมื่อจะทำการทดสอบความทนทานของกล้ามเนื้อลำตัว
