ENDURANCE OF LOW BACK MUSCULATURE: NORMATIVE DATA FOR ADULTS

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Abstract

Background and objective: Lack of baseline values is a limitation in the quantification of physical performance testing of the low back muscles. The purpose of this study is to present an age and gender normative values for static back extensor muscles' endurance in adults.

Subjects and Methods: Five hundred and sixty one healthy adults aged between 19 to 67 years volunteered for this study. Endurance of the low back musculature was assessed using modified Biering-Sørensen test of Static Muscular Endurance. The mean, standard deviation, and percentile scores for endurance time were determined for five gender / age groups classified on a range of 10 years.

Results: The mean endurance time of all the participants was 113±46 seconds. Men had higher mean endurance than women ($t = 3.309$; $p = 0.001$). Significant difference ($F = 32.702$; $p = 0.001$) was found in the endurance time across the age groups. There was an age and gender variation in the percentile values. The normative values demonstrate that a decrease in endurance time is expected with increasing age. The significant age and anthropometric differences across the age groups could contribute to the endurance differences.

Conclusion: These values could be used to compare a patient's score at intake and also serve as clinical target for which subsequent testing after treatment, at discharge and/or follow up can be compared, providing an indication of change in endurance capacity over time.

Keyword: Static endurance, low back muscles, Sørensen test, normative data, healthy Nigerians

Introduction

Low back pain (LBP) is a significant public health problem affecting 60 to 80 percent of the adult population [14]. Low levels of endurance of the back muscles are reported as a cause and effect of LBP [1, 19, 42, 58]. Similarly, low endurance of the back muscles has been implicated as a major reason for chronicity and recurrence of LBP [17, 12]. It has been reported that the evaluation of the endurance of back extensor muscles seems to have greater discriminative validity than evaluation of maximal voluntary contractile force [4, 16, 21, 26]. However, muscular endurance of the back extensors seems to be assessed less frequently than muscular strength [45], although the endurance capabilities of these muscles may be as important or even more important than strength in the prevention and treatment of LBP [57].

Measuring the endurance capacity of the low back muscles is important to the physical therapist in the rehabilitation of the back. Information on endurance capacity of the low back musculature may assist in determining levels of spinal pathology, guidelines for treatment and response to treatment. Back extensor muscles are classified as postural muscles [22] that aid in maintaining the upright standing posture and controlling lumbar forward bending [5], they are rich in larger diameter type I muscle fibres and are suited to support low levels of activity for long periods of time [40]. When these muscles are fatigued, researchers have hypothesized that changes in intersegmental motion around the neutral zone can lead to spinal instability [44]. A decrease in back muscle endurance could be implicated in clinical instability and pain [46]. According to Roy et al [49] these muscles consistently demonstrate a higher fatigue rate in patients with LBP. Previous studies have shown that people with poor back extensor muscle endurance have a low fatigue threshold which may predispose them to back injury by stressing the passive supporting structures [6, 51]. It is thought that decreased back muscles' endurance causes muscular fatigue and overloads soft tissue and passive structures of the lumbar spine, resulting in LBP [32, 59].

The endurance capacity of the back extensor muscles can be measured by both simple isometric and more sophisticated isokinetic dynamometers [15, 18]. The high cost of the dynamometric methods for trunk muscles assessment has raised questions about the real benefits of the expensive and complicated test machines [2, 50]. However, the non-dynamometric methods are reported valid and reliable in the assessment of low back muscles' endurance [2, 8, 41]. The Biering-Sørensen test of static muscular endurance (BSME) is a non-dynamometric clinical method for diagnosis of low back muscular endurance and requires no equipment. The BSME has been reported to be valid, reliable, safe, practical, responsive, easily administered, inexpensive, and there is a substantial quantity of compiled data [1, 2, 8, 41, 57]. The BSME or Sørensen test provides a global measure of back extension endurance capacity [41]. The BSME either in its original version or as variants has been widely used in previous research among healthy and patient populations [35]. The BSME as been used as a predictor of low-back health, based on endurance time [4, 52].

It is uncertain whether low endurance values are the cause or the consequence of LBP [37]. However, the frequency of low-back trouble has been shown to be greater in groups with decreased endurance of the low back musculature [12, 26, 43]. Previous studies have also established a significant difference in back extensor muscle endurance capacity between subjects with and without LBP [4, 16, 17, 21, 33]. Lack of baseline values is a limitation in the quantification of physical performance testing of the low back muscles. To identify alterations of the trunk musculature from "normal", it is necessary to reference normative database [37]. With the use of normal endurance values as a baseline, clinicians who treat LBP are able to determine departures from the norm [37] and also identify the presence of an impairment and in turn inform the plan for appropriate intervention based on the assessment of the extent of the muscular dysfunction [35]. McIntosh et al [37] submitted that the objective quantitative data provide benchmarks for setting specific goals to increase muscle performance capacity and provide outcome measures for evaluating the success of an intervention. Comparing test results to normative percentile data allows for assessment of which muscles exhibit dysfunction and to what degree. Literature contains little data concerning normal endurance capacity of the back muscles using the Sørensen test [1, 35 - 37]. The purpose of this study is to present an age and gender normal values for static back extensor muscles' endurance in adults.

Subjects and methods

Participants consisted of 561 non-smoking healthy volunteers, 297 men and 264 women from Obafemi Awolowo University Campus, Ile-Ife, Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife and Ile-Ife town, Nigeria. The participants ranged in age from 19-67 years and for statistical purpose they were categorized into five age groups, each with a class range of 10 years. Ethical approval for the study was obtained from the Ethics and Research Committee of the OAUTHC, Ile-Ife, Nigeria. The participants were fully informed about the purpose of the study and their consents were obtained before measurements were taken.

All participants were screened via interview to ensure that they satisfied the inclusion criteria for the study. Participants were excluded if they reported a history of symptomatic LBP within six month to the time of the study, if they reported a history of cardiovascular diseases contraindications to exercise, if they reported any participation in elite sports or involvement in any prior systematic exercise program of the lumbar or hip extensor muscles, and if they were pregnant, and if they have any disability limiting the ability to exercise, and if they had any obvious spinal deformity or neurological disease.

Measurements:

Anthropometric measurements included height, weight, Body Mass Index (BMI), and torso length (TL). A height meter (ISO 9001:2000 Mod BR9011) calibrated from 0-200cm was used to measure the height of each participant to the nearest 0.1cm. The participants' heels, back and occiput were touching the stadiometer scale with the participants looking straight ahead during measurement. Body weight in light clothes was measured to the nearest 0.1 kg using a weighing scale (ISO 9001:2000 Mod BR9011) calibrated from 0 – 120kg with the participant in standing and shoes off. A tape measure was used to TL with the participant in an erect position; the distance from the anterior superior iliac spine to the acromion process was measured and recorded in cm [7]. BMI was calculated by dividing weight in kilograms by height in meters squared (Wkg/Hm^2).

Procedures:

The BSME was used in the assessment of back extensor muscles endurance [4]. We adopted the same testing procedure as described in our previous publications [20, 35]. The participant lies on the examination table in the prone position with the upper edge of the iliac crests aligned with the edge of the table. The lower body was fixed to the table by two non-elastic straps, located around the pelvis and ankles respectively with a towel used to relieve stress on the ankle joint. With the arms held along the sides touching the body, the participant was asked to isometrically maintain the upper body in a horizontal position. Horizontality was ensured by asking the participant to maintain contact between his/her back and a weighted ball hanging from a Guthrie Smith frame. Once a loss of contact with the suspended weighted ball for more than 10 seconds was noticed the participant was encouraged once to immediately maintain contact again. If the position was not immediately corrected or if the participant claimed he could no longer hold the position due to fatigue, discomfort or pain the test was ended. The total time from the onset of the test to trunk flexion and loss of the static neutral position was recorded as the endurance time or the isometric holding time (in seconds) with the stop watch (Quartz U.S.A). The test was conducted only once and thereafter the participants were discharged. The test was conducted only once and thereafter the participants were discharged.

Data analyses

Data were summarized using the descriptive statistics of mean, standard deviation and percentile and charts. Inferential statistics involving independent t-test, Pearson's product moment correlation and analysis of variance (ANOVA) was also used. The alpha level was set at 0.05. The data analyses were carried out using SPSS 13.0 version software (SPSS Inc., Chicago, Illinois, USA).

Results

The mean age, height, weight, BMI and TL of the participants were 36.8±13.3 years, 1.66±0.09m, 65.2±11.7Kg, 23.5±4.09 Kg/m^2 and 43.8±6.39cm respectively. The general characteristics and endurance time of all the participants are presented in Table 1. The mean endurance time of the participants was 113 ±46s. Table 2 shows the independent t-test comparison of the general characteristics and endurance time of the participants by gender. The result indicates that men had a significant ($t = 3.309$; $p = 0.001$) higher endurance time than women. Table 3 shows the result of the One-way ANOVA and LSD post–hoc multiple comparison anthropometric parameters and endurance time of the participants across the different age groups. Endurance time decreased significantly with increasing age ($F=32.702$; $p = 0.001$). The post-hoc analysis showed that endurance time differed significantly between paired groups, except between age groups 50-59 and 60+ years. The result of Pearson's product correlation between endurance time and the dependent variables among all participants is presented in Table 4. Each of age, weight and BMI showed a significant ($p = 0.001$) inverse relationship with endurance time. However, no significant correlation was observed between endurance time and each of height and TL ($p>0.05$).

The participants were classified into five age groups of approximately 10-year interval; 19-29, 30-39, 40-49, 50-59 and 60+ for the purpose of constructing gender and age reference value charts for static back extensor endurance. The normative mean and percentile chart for static back extensor muscles' endurance for male and female participants are presented in figure 1 and 2 respectively. Percentile values were used as cut-off point to define good, medium and poor endurance respectively among both genders. Poor endurance was defined as position-holding time that is less than the 25th percentile, medium endurance was defined as a position-holding time that ranged between the 25th percentile and 75th percentile, while good endurance was defined as position-holding time that is greater than 75th percentile.

Discussion

This study presents a gender and age-referenced data for static back extensor muscles' endurance. It is recommended that clinicians who treat LBP can use established baseline data on low back endurance among normal subjects as a means to recognize decreased back muscles endurance as one of the impairments resulting from LBP or as an outcome measure to help evaluate residual disability [35]. Identifying high or low muscular endurance can alert the patient and clinician to a need for possible modifications to the usual treatment regime [37]. The extent to which a patient's back endurance level deviates from the norm for his or her gender and age group can be used in the diagnosis of low back endurance [35, 37].

Similar to a previous study by Mbada et al [35], it is suggested that percentile values can be used as cut-off point to define static back muscles' endurance as good, medium or poor respectively. However, it is important to note that the defined endurance categories may at best be useful for descriptive purposes. This is because poor endurance may not necessarily translate to LBP or vice versa. McIntosh et al [37] submitted that is uncertain whether low endurance values are the cause or the consequence of LBP. This is because a number of environmental, constitutional and behavioural factors have been associated with endurance of low back muscles [48]. Nonetheless, the frequency of low-back trouble has been shown to be greater in groups with decreased endurance of the low back musculature [12, 26, 43].

Environmental factors, such as physical activity and lifestyle, have been shown to influence isometric trunk force and trunk extensor endurance test results [16, 28]. Several constitutional factors are known to exhibit some association with back function test results such as age [1, 13, 23] and different anthropometric factors [13, 23, 30]. Also behavioural and lifestyle factors play a role in back function, such as motivation [9, 24], the presence of back pain [1, 13], health [13, 28], profession and education [1] and physical activity [13, 16, 28]. Back muscle endurance capacity also appears to be influenced by attitudes and beliefs about self-efficacy and self-assessed health [13, 28]. Smoking and obesity have shown inconsistent associations with back endurance [13, 23, 36, 39]. Also, aerobic or competitive sport has been implicated to play an influential role on back endurance [47]. Therefore, interpretation of results of back extensors endurance tests are complicated by the interactions of the various factors that could significantly influence endurance capacity of the back extensor muscles.

Normative data for static back endurance in the general population have emanated from few countries such as USA [34], Finland [1], and Canada [36]. Similarly, mean values for static back endurance have been documented from previous studies among normal adult subjects for different populations. Table 6 presents the comparison of the norm endurance time between the present study and some reported by others. The mean endurance values obtained in this study are lower than some reported among some western populations as shown in Table 5. Mbada et al [35] opined that ethnic and racial differences may have strong influence on pattern of low back endurance. Normative data obtained in the present study is comparable to a previous reference data by Mbada et al [35] among Nigerians from an urban metropolis (Table 6). Variations in endurance time norms from different regions and populations could be due largely to anthropometric differences among other factors. Anthropometric measures are reported to be population-dependent and vary from race to race [11]. For example, it is submitted that both African and African American have longer extremities and shorter trunk dimensions than do persons of European ancestry, although they are similar in height [10]. Hence, reference values of static back extensor muscles' endurance for specific populations are necessary. Also, numerous methodological variations and sample size differences from previous studies may translate into considerable discrepancies in results.

The results of this study showed that mean endurance time of men was greater than that of the women. Numerous studies on the neuromuscular characteristics of the back extensor muscles have demonstrated an association between gender and endurance capacity, with healthy women demonstrating higher endurance than men [23, 29, 57]. However, this was denied in other studies reporting lower endurance among women than men [1, 34]. Several hypotheses have been put forward to explain this gender-related difference. The trunk geometry of females and males differs [31]. Due to the gender dependent differences in body segment proportions (females generally have shorter legs and longer torsos than men); hence the forces differ between males and females [54] and such factors can significantly impact variables such as spine loading [31]. In females the weight of the upper body is believed to be less and the centre of gravity of the trunk lowers as compared to males [21]. Also, the greater degree of lumbar lordosis in females may afford a mechanical advantage by lengthening the lever arm of the spinal erector muscles [27, 55]. Contrarily, the result of this study indicates that men had a higher torso length than women. This may account for the different gender pattern in static back endurance observed in this study. Other investigators suggest that sex hormones may also have an influence on the difference in back endurance between genders [21, 29]. It is adduced that behaviour and lifestyle differences could account for the gender pattern in static back endurance observed in this study. For example, in Nigeria men are generally more active and take part in intense physical activities than do women. Also, higher weight and BMI observed among the women in this study may have influenced the gender pattern in endurance, as inverse associations such as observed in this study has been reported to lead to decrease static back endurance [13, 30, 48]. Height and torso length showed no significant correlation with the ability to perform on the endurance test among all the participants in this study. This is consistent with the report of Clark et al [7] who reported that the gender difference observed during the isometric endurance testing was not influenced by torso length.

The result of this study showed a significant decline in back endurance with advancing age. Nonetheless, no significant difference was found in the endurance time of those in age group 50-59 and 60 + years. However, this result is consistent with previous reports that muscle endurance decrease with increasing age [1, 4, 47,]. Mbada et al [35] summarized that decreased endurance observed with increasing age could be attributed to poor muscle function as a result of decreasing muscle mass, age related decline in strength which appears to be greater in back and lower extremity muscles, and decreasing aerobic capacity average of approximately 1% per year after third decade. Back muscles are characterized by a predominance of type I fibres [21] and are suited to support low levels of activity for long periods of time [38]. It was speculated that the magnitude of atrophy and reduction of type I muscle fibres of the back muscles associated with aging is more than that of the type II fibres [25]. It is believed that this selective loss of fibre associated with aging could result in a relative decrease endurance capacity [3].

From the result of this study, significant differences were found in the anthropometric parameters across the different age strata; also weight and BMI were found to be significantly related to endurance time. The significant anthropometric relations could contribute to difference in endurance time across the different age strata. Previous investigators have reported anthropometric measures such as BMI, weight, height, and body fat to influence back endurance capacity [13, 23, 30]. Ropponen et al [48] opined that anthropometric parameters appear to be of importance in low back muscle performance. Gibbons et al [13] reported that anthropometric factors had a comparatively minor role, to increase and sustain back muscle function in healthy adults as regards static back extensors endurance test. Body fat and lean body mass in previous studies have been shown to have relative influence on back muscle performance test results [13]. However in other studies, neither body weight [39, 57] nor mass moment of the trunk [16] influenced the position-holding time.

A potential limitation of this study was the sample bias resulting from voluntarily participation. Furthermore, selection criteria in this study were based on self report. Like every other study involving self-report, it is possible that the participants might have given vague answers to the questions in the selection process.

Conclusion

This study established normative static back endurance values according to age and gender among healthy adults. The normative endurance values derived in this study would be useful in assessing impairment in the function of the back muscles in both healthy and patient populations. These values could be used to compare a patient's score at intake and also serve as clinical target for which subsequent testing after treatment, at discharge and/or follow up can be compared, providing an indication of change in endurance capacity over time. Percentile scores could be used to estimate the degree to which a patient's score departs from the norm based on age and gender. The result of this study confirmed an age and anthropometric influence static back endurance.

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Table 1: The general characteristics and endurance time of the participants

Variables	Mean ± SD	Minimum	Maximum
Age (yrs)	36.8±13.3	19.0	67.0
Height (m)	1.66±0.09	1.30	1.91
Weight (kg)	65.2±11.7	39.0	107.0
BMI (Kg/m^2)	23.5±4.09	15.5	37.5
TL (cm)	43.8±6.4	20.0	59.0
ET (sec)	113±46	18.0	300.0

Key: BMI = Body mass index; TL = Torso length; SD= Standard Deviation

Table 2: Comparison of the general characteristics and endurance time of the participants by gender

Variables	Sex	Number	Mean ± SD	t	p-value
Age (yr)	Men	297	37.2 ± 13.6	0.821	0.412
	Women	264	36.3 ± 12.9		
Height (m)	Men	297	1.71 ± 0.08	12.998	0.001
	Women	264	1.62 ± 0.08		
Weight	Men	297	67.1 ± 10.9	4.155	0.001
	Women	264	63.1 ± 12.1		
BMI	Men	297	23.1 ± 3.5	-2.791	0.005
	Women	264	24.0 ± 4.5		
TL	Men	297	46.5 ± 4.8	11.676	0.001
	Women	264	40.8± 6.6		
ET	Men	297	119 ± 47	3.309	0.001
	Women	264	106 ± 44		

Significance set at $p<0.05$

Key: BMI = Body mass index; TL = Torso length; SD= Standard Deviation

Table 3: Comparison of the general characteristics and endurance time among the participants in the different age stratification (n = 561)

Variables	19 – 29 N = 210 X ± S.D	30 – 39 N = 103 X ± S.D	40 – 49 N = 128 X ± S.D	50 – 59 N = 89 X ± S.D	60+ N = 31 X ± S.D	F-ratio	p-value
Age	23.2 ± 2.42[a]	33.4 ± 2.86[b]	43.4 ± 3.03[c]	53.8 ± 2.57[d]	62.8 ± 3.01[e]	3142.2	0.001
Height	1.68 ± 0.08[a]	1.66 ± 0.09[b]	1.65 ± 0.11[b]	1.64 ± 0.08[b]	1.65 ± 0.07	4.374	0.002
Weight	63.3 ± 9.7[a]	64.5 ± 11.7[a]	66.9 ± 13. 7[b]	66.7 ± 12.2[b]	69.2 ± 11.7[c]	3.529	0.007
BMI	22.4 ± 3.19[a]	23.3 ± 4.05[b]	24.2 ± 4.48[b]	24.8 ± 4.58[b]	25.1 ± 4.44[c]	8.726	0.001
TL	44.8 ± 6.10[a]	43.8 ± 5.65	42.8 ± 7.70[b]	42.9 ± 6.45[b]	44.0 ± 2.48[a]	2.632	0.033
ET	133 ± 41[a]	121 ± 49[b]	103 ± 42[c]	82 ± 36[d]	81 ± 33[d]	32.702	0.001

Superscripts (a,b,c,d,e).

For a particular variable, mode means with different superscript are significantly (P<0.05) different. Mode means with same superscripts are not significantly (P>0.05) different. When only one contrast is significant, one of the cell means has no superscript attached. The pair of cell means that is significant has different superscripts.

Key: BMI = Body mass index; TL = Torso length; SD= Standard Deviation

Table 4: Pearson's product correlation between endurance time and the dependent variables among all participants (n=561)

Dependent variables	Correlation coefficient (p-value)
Age (Year)	- 0.428** (0.001)
Height (m)	0.062 (0.144)
Weight (kg)	-0.337** (0.001)
BMI (kg/m²)	-0.396** (0.001)
TL (cm)	0.034 (0.424)

Key: BMI = Body mass index; TL = Torso length; SD= Standard Deviation

** indicate significance at p=0.01

Table 5: Comparison of the norm endurance time between the present study and some reported by others

Age range	Country	Male				Female			
		No.	Mean	Minimum	Maximum	No.	Mean	Minimum	Maximum
Present study 19-67	Nigeria	297	119	18	300	264	106	25	225
Mbada et al [35] 21 – 60	Nigeria	190	119	28	240	183	106	22	236
Biering-Sørensen [4] 30-60	Finland	144	195	---	---	152	199	---	---
Kankaanpää et al [23] 26 - 67	Finland	100	154	---	---	133	183	---	---
Hultman et al [17] 45 – 55	Sweden	36	150	---	---	---	---	---	---
Holmström et al [16] ---	Sweden	40	172	119	266	---	---	---	---
Nicolaisen and Jörgensen [43] 27 - 60	Denmark	24	184	---	---	8	219	---	---
Manion and Dolan [29] ---	UK	21	116	---	---	208	142	---	---

Key: --- = Not Available

Figure 1: Normative Mean and Percentiles for Static Back Endurance (Male)

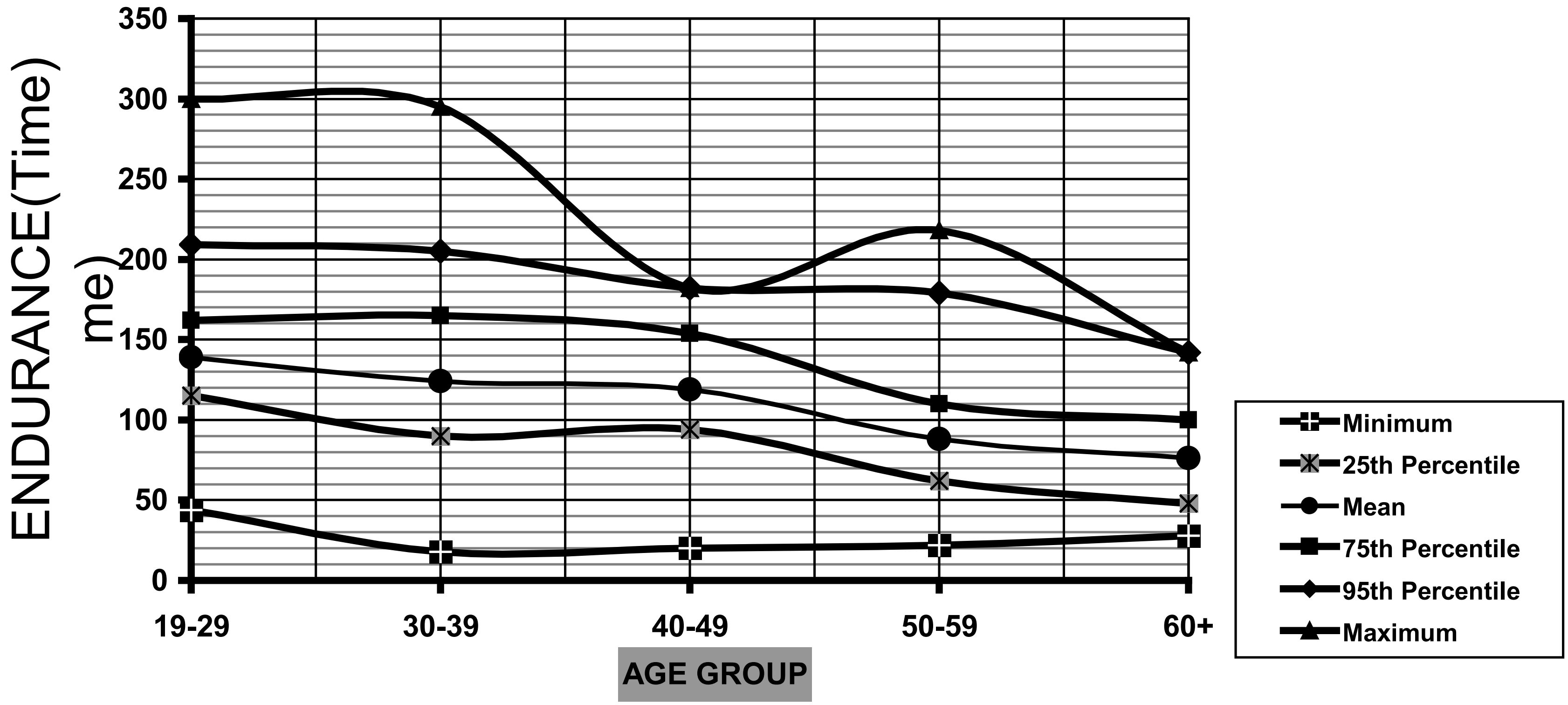

Figure 2: Normative Mean and Percentiles for Static Back Endurance (Female)