Research Article



Relationship between neck circumference and abdominal adiposity in young adult males and females

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Abstract

Practitioners and clinicians employ several anthropometric measurements including body mass index, waist-to-hip ratio, weight-to-height ratio, and waist circumference to assess risk of hypokinetic-related diseases. Limited research exists on whether neck circumference may be used as another anthropometric tool to asses an individual's health risk. Therefore, the purpose of this investigation was to determine the relationship between neck circumference and abdominal adiposity amongst a young, adult population. Subjects (N = 61 females; N = 58 males; age = 19.8 yrs \pm 2.0 yrs; height = 170.4 cm \pm 7.6 cm; body mass = 65.3 kg \pm 10.4 kg) provided informed consent. Pearson correlations were used to determine the relationship between neck circumference and abdominal adiposity. The correlation between neck circumference and abdominal adiposity was moderate (r = .40, p = .002) for males, whereas, moderately high (r = .69, p < .001) among females. Neck circumference is related to abdominal adiposity within this sample of young male and female adult participants. From a practical perspective, clinicians and practitioners may use neck circumference, collectively with other anthropometric tools, to determine an individual's health risk.

Introduction

In today's society, it is intuitive that an increased amount of body fat, increases the risk of health problems such as, but not limited to, high blood pressure, heart disease, cardiovascular disease, diabetes, cancer, and sleep apnea [1]. Early, if not earlier, detection and education are important steps to helping these individuals lead a healthier life insofar as to prevent obesity, which would be the ultimate goal for a healthy nation. There are numerous scientific equipment(s) and/or instrumentation(s) that health professionals utilize to determine a person's obesity level, specifically, body composition. Some of the many body composition analytical equipment(s) and/or instrumentation(s) are, but not limited to, skinfold calipers, hydrostatic weighing, and dual energy x-ray absorptiometry (DXA).

While skinfold calipers and hydrostatic weighing techniques are amongst the most commonly-used assessment tool to quantify body composition, to date, the 'gold standard' of calculating body composition, however, is the DXA [2-4]. The distinct advantage of the DXA is the information that it provides for its clients. Conversely, the disadvantage of the DXA analyses, aside from the cost of the equipment and analyses, is that it emits radiation, albeit minute, upon the client. Most individuals do not prefer to have excess radioactive exposure above what individuals are currently exposed to, and as such, prefer not to be analyzed *via* DXA.

Due to these aforementioned drawbacks of the DXA, researchers, practitioners, and clinicians are seeking other tools, more precisely, anthropometry tools such as body mass index (BMI), waist-to-hip ratio, and/or neck circumference that are simple, relatively inexpensive, and non-invasive, but provide relatively accurate data regarding the health risk(s) for clients. The BMI is a number that is derived *via*: body mass (kg) \div height (m²). The information that BMI provides for practitioners and/or clinicians is the magnitude of a client's obesity. As such, BMI value between 25.0 to 29.9 kg·m² is categorized as overweight, whereas,

an index of >30 kg·m² is categorized as Class I obese [5]. The advantages of quantifying BMI are that it is non-invasive, it is inexpensive, and requires relatively little time or effort to perform the assessment. Having said that, the distinct advantage of this anthropometric tool is its capability to assess mass population in a non-invasive manner. The disadvantages, however, is that BMI does not consider the composition of body mass. More specifically, individuals that are within the athletic/ physically-active realm will be categorized inaccurately (*i.e.*, overweight or obese) due to the heavier body mass relative to height, when these physically-active/athletic individuals have a large volume of lean body mass relative to fat mass.

Another anthropometric measurement tool that is commonly used by clinicians/practitioners is waist-to-hip ratio. Waist-to-hip ratio is used to determine individuals' susceptibility of obtaining some form of hypokinetic-related disease. Practitioners and clinicians measure the waist-to-hip ratio *via*: waist circumference \div hip circumference. Once calculated, a value of < 0.86 is considered ideal for females, while < 0.95 is ideal for men [6]. The advantages of the waist-to-hip ratio are its simplicity, cost efficiency, accessibility, and practical as individuals simply use a measuring tape, calculate an individual's ratio, and compare it to a norm chart. Although this anthropometric tool is generally an acceptable measure, a disadvantage of this assessment is that it may be uncomfortable and somewhat invasive for respective clients being measured due to the exposure of the midsection.

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Compared to the vast literature with respect to BMI and waist-tohip ratio, a relatively novel anthropometric technique for clinicians and practitioners have been measuring neck circumference and correlating its measurement to the magnitude of obesity in children, adolescents, and adults [7-17]. Against this backdrop, the primary aim of this current study, therefore was to determine the relationship between neck circumference and abdominal adiposity. It was hypothesized that there would be a relationship between neck circumference and abdominal adiposity. The impetus for this study was not to replace the current, existing anthropometric tools assessing individual's health status, but rather, add another anthropometric tool to be placed within the practitioner's and/or clinician's assessment kit. With that said, findings gleaned from this study shall allow practitioners and/or clinicians to use neck circumference, in addition to BMI and waist-to-hip measures, as another informative tool to collectively assess a client's overall health status, specifically, risk and/or susceptibility of attaining some form of chronic-related diseases.

Materials and methods

Subjects

Upon approval by the University's Institutional Review Board, voluntary participation was sought from 119 physically-active males and females. The young, active subjects participated in various sports such as track and field, swimming, cross country, soccer, and volleyball. A physical activity questionnaire and informed consent form were completed and signed by each participant. The aim of the physical activity questionnaire was to determine the amount of physical activity levels, specifically, frequency, intensity, duration, and mode for each participant. Prior to the participant's initial lab visit, participants were asked to refrain from performing vigorous upper and/or lower body strength training and/or cardiovascular endurance exercises as this may influence land body mass, hence, body composition results. Participants were also advised to refrain from eating and/or drinking directly before the testing session due to the justification. That said, participants were physically prepared, adorned the proper attire, and were informed of what to expect throughout the course of the study.

Procedures

Participants arrived at University of North Carolina Wilmington's Human Performance Laboratory during the appointed day and time. Participants attended one laboratory session. The purpose of the solo data collection session was to collect subject's height, body mass, neck circumference, and abdominal adiposity. Once informed consent was obtained, participants changed into the appropriate attire (i.e., shorts, loose-fitting t-shirt, no shoes, socks, jewelry, rings, or bracelets), a technician measured the participant's height. Participant's height was assessed with both legs together, with calves, buttocks, and upper back placed firmly up against the measurement wall. Each participant's height was measured to the nearest 0.1 cm. Additionally, each participant's body mass was recorded to the nearest 0.045 kg via Tanita BWB-800 Electronic Scale (Japan). Once height and body mass were recorded, a research assistant measured the participant's neck circumference with a Gulick Measuring Tape (USA) to the nearest 0.1 centimeter (cm). More precisely, neck circumference was measured as the largest, sagittal circumference of the thyroid caritilage. For participants with prominent thyroid cartilage, neck circumference was taken right below the most prominent protrusion of the thyroid cartilage. The objective of quantifying neck circumference right below the most prominent protrustion of the thyroid cartilage was to replicate what was performed in previous literature [7,9,15,16]. All height, body mass, and neck circumference measurements were recorded twice. If measurements exceeded 1 cm, then additional measurements were taken until all measurements were within 1 cm.

Once participant's height, body mass, and neck circumference were recorded, participant's abdominal adiposity (grams) and percent body fat (%BF) were quantified *via* General Electric Dual Energy X-ray Absorptiometry Lunar Prodigy Advance enCORE (USA). The DXA was calibrated on a daily basis prior to data collection. Calibration procedures were set forth by the manufacturer guidelines and adhered to prior to data collection. After the DXA was calibrated, the technician asked the participant to lie down, face-up, on the blue mat, with arms/ hands resting comfortably by their side with both legs/feet relatively close together. Once positioned within the DXA, one total body DXA scan was performed. The scan took 5-6 minutes and provided immediate results. Upon completion of the DEXA scan, subjects dressed back into their original clothing and exited the Human Performance Laboratory.

Statistical analyses

Descriptive statistics (mean \pm SD) were computed to describe the subject population. Pearson product-moment correlation (SPSS version, USA) was used to determine the relationship between neck circumference and abdominal adiposity. For all analyses, statistical significance was established at $p \leq 0.05$.

Results/discussion

The primary aim of this study was to determine the relationship between neck circumference and abdominal adiposity. The rationale as to why neck circumference was chosen were twofold. The first reason was due to the ease of location, non-invasiveness, and rapidity of measurement for this particular anthropometric site. The second reason was the relative dearth of scientific investigations conducted examining the relationship between neck circumference and abdominal adiposity measured *via* DXA.

Upon collecting and analyzing the data set on 119 subjects, Table 1 reveals the descriptive and anthropometric measures of all study participants. As revealed in Table 2, paired t-test revealed a difference ($p \le 0.05$) in both neck circumference and abdominal adiposity between males and females. As such, due to said sex differences in both neck circumference and abdominal adiposity, analyses for males and females were done separated. As displayed in Table 3, results from the Pearson product-moment correlation analyses revealed a moderate (r = .40, p = .002) relationship for males and moderately high (r = .69, p < .001) relationship among females. To this end, the ensuing paragraphs will compare the current findings within this study to other previouslymentioned scientific studies.

In 2002, Laasko and colleagues revealed a link between neck circumference and other anthropometric measurements, such as BMI, waist-to-hip ratio, waist circumference, and hip circumference. More specifically, Laasko and colleagues [11] examined the relationship

Table 1. Descriptive measurements of the study participants (N = 119).

Variables	Mean ± SD
Age (years)	19.9 ± 1.7
Height (cm)	174.7 ± 8.2
Body Mass (kg)	69.8 ± 10.6
Body Fat (%)	19.1 ± 9.3
Abdominal Adiposity (g)	6136.0 ± 3373.4
Neck Circumference (cm)	34.3 ± 3.1

Table 2. Descriptive measure	ments of male and	female participants.
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Male (N = 58)	Female (N = 61)
20.1 ± 1.4	19.8 ± 2.0
179.2 ± 6.3	170.4 ± 7.6
74.6 ± 8.5	65.3 ± 10.4
11.5 ± 4.4	26.3 ± 6.6
4385.1 ± 2230.2	7800.9 3445.9*
36.9 ± 1.7	$31.8 \pm 1.6^{*}$
	Male (N = 58) 20.1 ± 1.4 179.2 ± 6.3 74.6 ± 8.5 11.5 ± 4.4 4385.1 ± 2230.2 36.9 ± 1.7

* $p \le 0.05$

Table 3. Pearson correlation between neck circumference and abdominal adiposity amongst males and females.

	Male Neck Circumference	Female Neck Circumference
Abdominal Adiposity	r = .40 *	r = .69 *
$p^* p \le 0.05$		

between neck circumference and abdominal and general obesity in 541 subjects. After partitioning the subjects into quintiles, it was revealed that neck circumference was related to the other anthropometric assessments associated with abdominal and general obesity. In comparison, the mean neck circumference within the current study for men and women (34.2 cm) was lower compared to the neck circumference measures (37.8 cm) in Laasko and associate's [11] study. Moreover, the men and women within Laasko and colleague's [11] study were shorter and heavier compared to the subject pool within the current study. The aforementioned data may explain why there was only a moderate to moderate-high relationship between neck circumference and abdominal adiposity amongst the men and women, respectively, compared to the stronger relationship revealed within Laasko and colleague's [11] findings. In other words, the men and women within the current study were taller, lighter, and had smaller neck circumference. As such, one may surmise that a stronger relationship was found within Lassko et al.'s [11] study because the subject sample were shorter, heavier, and had larger neck circumference compared to the sample population within the current study.

Similarly, Ben-Noun and Laor conducted a study in 2006 examining the link between neck circumference and cardiovascular disease risk factors. The researchers recruited and collected a multitude of anthropometric and physiological data from 431 men and women. Results of the study revealed a strong relationship between neck circumference and the various anthropometric and physiological data sets. For instance, there was a statistically significant correlation between neck circumference and BMI amongst men (r = .73) and women (r = .70) [7]. These researchers concluded that neck circumference was related to various risk factors for cardiovascular disease. As mentioned before, the sample population of Ben-Noun and Laor's [7] were heavier, shorter, and had higher neck circumference measurements compared to the current study.

Recently, in 2010, Hatipoglu and associates conducted a study to determine if neck circumference measurements alone may be used to determine the magnitude of obesity among 412 pre- and pubertal boys and girls. The results revealed a strong correlation between neck circumference and BMI values for boys and girls. These researchers concluded that neck circumference may be used to gauge the magnitude of obesity within pre- and pubertal boys and girls. The mean neck circumference for the pubertal boys and girls (35.1 cm) was very similar to the neck circumference (34.2 cm) of the current study. Given that the mean age of the current study was 19.9 ± 1.7 years and the maximum age for pubertal stage is 18 years, this compares nicely with what previous literature has revealed with respect to younger adult

men and women population.

All the investigations have revealed a link between neck circumference with several anthropometric assessments and physiological parameters. The greater the neck size, the greater the susceptibility of obtaining some form of hypokinetic-related disease(s). However, a common thread among the said studies was the lack of quantifiable percent body fat, more specific, the lack of information with respect to the link between neck circumference and abdominal adiposity. Hence, the unique aspect of the current study is the capability to link neck circumference with abdominal adiposity.

To date, there have been a few studies displaying the relationship between neck circumference and abdominal adiposity. The first study by Yang et al. [16] measured neck circumference and abdominal adiposity via computed tomography scan in 18 men and women. Results of the study revealed a moderately high correlation (r = .67)between neck circumference (44.1 \pm 4.6 cm) and abdominal adiposity [16]. The correlations revealed within Yang and colleagues [16] study is lower than the men, but very similar compared to women within the current study with respect to neck circumference and abdominal adiposity (r = 40 for men; r = .69 for women, respectively). However, Yang and associates [16] did not partition the data set between men and women, but rather calculated the mean of all 18 men and women, as it would have been nice to compare gender-specific results. In another study published in 2010, Preis and colleagues measured neck circumference and abdominal adiposity via computed tomography amongst 3307 men and women. These researchers revealed a statistically significant correlation between neck circumference and abdominal adiposity in men (r = .63) and women (r = .74) [15]. Because of these two aforementioned studies, there is a strong link between neck circumference and abdominal adiposity, hence, risk of obtaining any form of chronic-related disease(s) [15,16].

While the current data set somewhat mirrors to that of the previously-mentioned studies, it does not, however, reveal as strong as a link between neck circumference and abdominal adiposity. The differences may be due to several factors. The first is the mean age of the subject populations between the current study and the two aforementioned studies. For instance, the mean of age of the current data set (19.9 years) was much younger compared to Yang and associate's [16] study (44.9 years) and Preis and colleague's [15] study (51.0 years). Secondly, there is not only a large difference within the subjects studied within the three studies, but also, the subjects within the current study were much taller and lighter compared to both Yang and associate's [16] and Preis and colleague's [15] research studies. As such, one may speculate that as one gets older, shorter, and heavier, not only does neck circumference rise, but also, the individual's risk levels of attaining some form of cardiovascular-related disease.

In summary, the aim of this investigation was to determine the relationship between neck circumference and abdominal adiposity. The analyses revealed a moderate and moderately-high correlation between neck circumference and abdominal adiposity amongst men and women, respectively. Based on these findings, neck circumference is related to abdominal adiposity. From a practical perspective, clinicians and practitioners may use neck circumference, collectively with other anthropometric tools, to determine an individual's health risk.

Viewed in concert, there are two take home messages from this study. The first is that neck circumference is related to abdominal adiposity in both males and females. Therefore, neck circumference can be used as an additional anthropometric tool by health professionals to help determine health risks associated with obesity-related diseases. Secondly, it is clear that many more participants of greater age range and fitness levels should be examined in order to truly determine the relationship between neck circumference and abdominal adiposity. With further research validating the use of neck circumference, clinicians and practitioners may confidently use neck circumference along with the other anthropometric tools to collectively gauge a client's magnitude of risk level of cardiovascular-related disease(s).

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