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SIDE TO SIDE DIFFERENCES BETWEEN DOMINANT AND NON-DOMINANT ARM'S BONE DENSITY AND ISOMETRIC HANDGRIP STRENGTH IN MALES AND FEMALES AGED 40-65 YEARS OLD

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ABSTRACT

Objective. This observational, cross-sectional study, investigates and compares the differences of BMD, T-score, Z-score and isometric strength between dominant (D) versus non-dominant (ND) arms of 162 subjects aged 40-65 in a developing, low income country (Kosova). **Material and Methods.** Bone Mineral Density (BMD), T-score and Z-score at distal forearm regions of both arms (measured by DXA scan), together with the Handgrip Isometric Strength (HIS) (by handgrip) were evaluated in a total subjects (53 Males and 109 Females). Additionally, General Healthcare Status Questionnaire together with self-administrated International Physical Activity Questionnaire (IPAQ) were filled. **Results.** Significant differences (p<0.05) between arms were found in BMD, T-score, and Z-score in total subjects and in females, whereas not significant differences (p>0.05) were observed in Males BMD comparing to significantly higher results (p<0.05) in T-score and Z-score. Significant differences (p<0.05) were also found in total subjects and in females handgrip, but not (p>0.05) in males. When comparing the total subject's BMD, T-score, Z-score and Handgrip based on the PA levels (1 to 3 according to IPAQ scoring) no significant differences (p>0.05) were found between PA1, as well as PA3 whereas significantly differences (p<0.05) were found in D arms of PA2 level. **Conclusion.** The study analyses side-to-side differences in bone density and muscular force between D and ND arms amongst a population which is frequently exposed to diagnostic screenings for age related osteomuscular conditions (aged 40-60), and demonstrates that these differences should be in consideration amongst clinicians, but not in the way it is done right now.

Key words: Bone Density, Physical Activity, Muscular Force, DXA scan.

1. INTRODUCTION

The process of age-related loss of bone mass and density is a subject of current concern (1), with an ever growing interest for conditions deriving from it, such as Osteoporosis and Osteopenia.

The evaluation of bone density can be performed by various methods such as bone densitometry, bone ultrasound, tomography and radiographic exams (2). The gold standard and probably the most effective technique is Dual Energy X-ray Absorptiometry (DXA), for which studies have shown that provides accurate and precise composition analysis with a low radiation exposure (<0.1mGy) (2, 3, 4).

DXA provides a full body scan (measuring different sites) or a regional scan (concentrated on a specific region). When performed on distal forearm, DXA is recommended to be realized on the distal one third (33%) radius of the ND forearm for diagnosis (5, 6, 7). The exclusion of D side for clinical diagnosis opens a gap for many questions. If physical activity presents a possible factor that might affect the D, does this account for athletic populations only or for sedentary populations as well?! Additionally, how accurate could be the clinical diagnosing performed on the D side, if the subject lacks the ND forearm and the full body DXA scan is unreachable.

When looking within the published work done up to now, a few studies measured side to side differences in distal radial bone, but almost all of them were concentrated on either effect of a specific sport (8, 9, 10, 11), a particular behavior (10, 11, 12), or after a specific health condition (13). A study from *Hildebrandt EM, et al* found significant differences ($p<0.05$) between D and ND radial and tibial sites in males, and only tibial sites in females, but was performed using a different technique (pQCT) with a big gap of age within subjects (males and females aged 16-72 years old) (14).

In contract to this, a previous study of ours which was concentrated in measuring side to side differences in D versus ND arms on distal radial bone, between female athletes (soccer and handball players) and sedentary females, during their peak bone age (17-30), evidenced no significant differences ($p>0.05$) in sedentary young adult females (11). Yet, no previous study has evaluated the D versus ND differences in radial bone density of older subjects, especially subjects by their late adulthood (40-65), which are more prone to age-related loss of bone mass and density, consequently in need for DXA scans.

2. MATERIAL AND METHODS

Study design and population

A prospective observational and cross-sectional research study, was performed in the Shkumbini SB Clinic, from July to October 2015. A total number of 162 subjects (53 or 32.7% Males and 109 or 67.3% Females) aged between 40 to 65 years old took part.

All procedures performed in the study involving human participants were in accordance with the ethical standards of the national research committee (Committee of Ethical and Professional issues of University Clinical Center of Kosova–UCCK), reference number 797/12/03/2015 and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Before measurements, every participant was completely informed about each procedure of this research, the exact purpose of the study, the levels of X-ray radiation and a clear message of voluntary principal of participation, while an informed and singed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

Subjects were recruited on the principle of first come, once they fulfilled the inclusion criteria (age group and residency in Kosova), based on the announcements in local medias (TV and radios) and social networks (Facebook and Twitter). All the interested subjects older or younger than the set age, those with any medical condition where the application of X ray can be harmful and those not living in Kosova were excluded from the study. Every subjects name was codified in order to guaranty and protect individual data in accordance with the Law No 03/L-172 on protection of personal data in the Republic of Kosovo.

Study protocol

Every participant firstly went through filling two different questionnaires:

General Healthcare Status Questionnaire – a random anamnesis questionnaire provided by the University Clinical Center of Kosova (UCCK), was used to evaluate general healthcare status and previous medical conditions, helping for the inclusion criteria;

The International Physical Activity Questionnaire (IPAQ) was used to assess the subjects volume of PA by weighting each type of activity by its energy requirements (MET's – Metabolic Energy Requirement) for the last seven days (26), classifying the subjects on three groups according to the types of PA (Low–1, Moderate–2 and High–3) (26). translated and updated in Albanian from Boshnjaku A et al. (15).

Self-administered Nutritional Standard Questionnaire (NSQ) – that is used to evaluate nutritional intakes in the Italian surveillance system (28), modified by members of the department of Health Sciences, Universiy of Rome "Foro Italico", was used to assess nutritional intakes in our study subjects.

Anthropometric measurements

After completing the questioners, every participant has undergone anthropometric measurements, while each subject's weight and height was measured with clinical scale and stadiometer (respectively), with a precision of 100g (weight) and 1 mm (height). Deriving from these data's BMI (Body Mass Index) was calculated.

Assessment of bone density

BMD was measured by DEXA scan (Dual Energy X-ray Absorptiometry), with a host software version: 3.9.4. and scanner software version: 1.1.1 (NORLAND PDEXA bone densitometer device, Florida, USA). All the measurement were performed on the distal radial bone of both arms (D and ND), with the presence of radiologist Dr Antigona Kabashi. DEXA scan device was calibrated regulatory in prior to measurements (reference number: 1124), decimator 2199, 717 2143, 718, with a Phantom ID:2048, BD: 0.906 and BMD SD: 0.010.

Measurements were made in accordance with the WHO (World Health Organization) guidelines for clinical diagnosis of bone diseases: T-score <- 2.5, while Osteopenia–2.5 <T-score <-1.0 (16).

Assessment of muscle strength

Participants have performed two trials of an isometric handgrip strength test (kg), each of them interspersed by 1 min since this way the best results were documented (17, 18). While in a sitting position, subjects squeezed for maximal isometric contraction in a duration of 4–5 seconds, in a device adaptable to different sizes (SAEHAN Corporation, Masan, Korea). The highest result achieved was documented as the handgrip strength of the subject.

Statistical analysis

All statistical analyzes were applied using the program Graph Pad Prism 6 for statistical analysis and statistical significance set at $p<0.05$.

Descriptive statistics is generated for all the study variables, including here the mean average for continuous variables and relative frequencies for categorical variables. Differences between groups with continual data were performed using unpaired t test with Welch's correction (to compare two groups), one-way Anova (to compare three groups) and multi-way Anova (to compare more than three groups), whereas the differences between categorical variables were made by using x^2 test.

3. RESULTS

Descriptive statistics for bio-anthropometric and physical activity (PA) level results are shown in Table 1, where it can be seen that there is no age differences (p>0.05) between males and females, as well as in weight, while significant differences (p<0.05) are seen in height and BMI between males and females. Similar results were found when comparing PAL between genders, while females resulted physically more active than males.

When comparing BMD, T score and Z score of D versus ND forearms in total studied population, as well as when analyzing based on gender (Table 2), significantly better (p<0.05) results were found in D side in all the cases except for BMD in males where differences could be seen, but are not statistically significant (p>0.05). Significant differences were observed in Isometric Handgrip Strength in total study population as well as in females (p<0.05), but interestingly, not in males (p>0.05) (Table 2).

When comparing the total subject's BMD, T-score, Z-score and Handgrip based on the PA levels (1, 2, 3) between D and ND sides (Table 3), no significant differences (p>0.05) were found in PA1 group, as well as in PA3 in BMD, T-score and Handgrip while significantly differences (p<0.05) were found in Z score. In subjects with PA2 level significant differences (p<0.05) were found in all variables except Handgrip.

Similar results were also recorded when analyzing BMD, T score, Z score and Handgrip in D versus ND arms based on specific genders (Table 4 and Table 5), where statistically significant (p<0.05) results were recorded in BMD, T score and Z score and non-significant (p>0.05) results in Handgrip of PA2 group of males, whereas significant (p<0.05) results were recorded in all variables in females.

	Male (n=53)	Female (n=109)	P value	Total (n=162)
Age, in years	55.15 ± 7.12	54.27 ± 5.1	p>0.05	54.63 ± 6.56
Weight, in kg	78.21 ± 13.25	75.52 ± 11.01	p>0.05	76.4 ± 11.8
Height, in cm	173.06 ± 7.51	164.52 ± 5.58	P<0.05	167.3 ± 7.45
Body Mass Index, in kg/m^2	26.05 ± 3.73	27.95 ± 4.36	P<0.05	27.3 ± 4.26
Physical Activity Level (MET 1, 2 ose 3)	1.9 ± 0.83	2.4 ± 0.68	P<0.05	2.26 ± 0.76

Table 1. Subjects characteristics. MET Metabolic Equivalent of Task

	Males (D *vs.* ND)	P value	**Females (D *vs.* ND)**	P value	**Total (D *vs.* ND)**	P value
BMD	0.450 ± 0.09 vs. 0.421 ± 1.48	p>0.05	0.343 ± 0.07 vs. 0.317 ± 0.06	p<0.05	0.379 ± 0.09 vs 0.352 ± 0.08	p<0.05
T-score	0.44 ± 1.48 vs. 0.17 ± 1.07	p<0.05	-0.19 ± 1.47 vs. -0.69 ± 1.17	p<0.05	0.02 ± 1.51 vs -0.52 ± 1.16	p<0.05
Z-score	0.751 ± 1.37 vs 0.103 ± 1.01	p<0.05	0.75 ± 1.37 vs -0.1 ± 1.01	p<0.05	0.51 ± 1.30 vs -0.01 ± 0.95	p<0.05
HIS	38.49 ± 9.95 vs. 35.74 ±	p>0.05	26.75 ± 5.92 vs. 24.59 ±1.47	p<0.05	30.64 ± 9.32 vs. 28.24 ± 8.81	p<0.05

Table 2. BMD, T-score, Z-score and HIS in total subjects, males and females, dominant vs non-dominant. BMD Body Mass Density, PAL Physical Activity Level, HIS Handgrip Isometric Strength

	PA1 (D vs. ND)	P value	PA2 (D vs. ND)	P value	PA3 (D vs. ND)	P value
BMD	0.381±0.09 vs. 0.355±0.09	p>0.05	0.364±0.09 vs. 0.321±0.06	P<0.05	0.391±0.1 vs. 0.374±0.09	P>0.05
T-score	-0.34±1.32 vs. -0.91±0.97	P>0.05	-0.31±1.21 vs. -0.973±0.83	P<0.05	0.431±1.68 vs. -0.005±1.24	P>0.05
Z-score	0.222±1.19 vs. 0.259±0.65	P>0.05	0.192±1.05 vs. -0.463±0.68	P<0.05	0.874±1.42 vs. -0.437±1.04	P<0.05
HIS	31.71±9.88 vs. 28.78±9.01	P>0.05	29.82±10.03 vs. 26.72±8.99	p>0.05	31.03±8.5 vs. 29.19±8.32	p>0.05

Table 3. Total subject's BMD, T-score, Z-score and HIS based on the PAL (1, 2, 3) between dominant and non-dominant sides. BMD Body Mass Density, PAL Physical Activity Level, HIS Handgrip Isometric Strength

4. DISCUSSION

Side to side differences in bone density seem to be statistically significant (p<0.05) in females by their late adulthood (40-65 year old), which was the case only in T score and Z score in males (p<0.05), and not in BMD (p>0.05). A similar situation was found also in isometric muscle handgrip strength, where significant differences (p<0.05) were found in females only.

This is the first time that non-significant differences (p>0.05) were found in males when performing the distal radial DXA scan. Contradicting to this, non-significant differences (p>0.05) were found previously by Hildebrandt EM et al (using pQCT) only in female tibial sites, but not in female radial sites (p<0.05), nor male radial and tibial sites (p<0.05) (14). Yet, this study used pQCT for measurements and included subjects of a much wider age scope, 16-72 year old (14).

Similar to Hildebrands EM et al (14), in a previous study of ours, not significant differences (p>0.05) were found in 17-30 year olds sedentary females (measured by DXA at distal radial forearm) (11).

In other studies, significant differences (p<0.05) were found in 50-64 year old females of both Caucasian and Afro-American races (measured by DXA at hip site) by *Alele JD et al* (19), in 50-92 year old females (measured by DXA at hip site) by *Hamdy R et al* (20), as well as in female professional handball athletes aged 17-30 y.a. by *Boshnjaku et al* (11) and professional conditioned jumpers, conditioned triple jumpers, unconditioned jumpers, hurdlers and sprinters of both genders aged 20-80 years old (measured by pQCT on tibial site) by *Ireland et al* (8).

In contrary, but probably due to specific training requirements and particular exercising behavior, non-significant differences (p>0.05) were found in 17-30 year olds female professional football/soccer athletes (measured by DXA at distal radial forearm site) by Boshnjaku et al (11), as well as in 12-18 year olds male football/soccer athletes (measured by Peripheral Quantitative Computed Tomography – pQCT at lower leg site) by *Anliker E et al* (9).

Additional interesting results we registered when comparing side-to-side differences in BMD, T score and Z score based on the physical activity level groups (1 to 3 according to IPAQ scoring (15)) in total population and in both genders, where significantly better (p<0.05) results were registered in D sites only on those from PA 2 in all the cases. Up to now, no previous study investigated or encountered this phenomenon. Our results suggest that side-to-side differences in bone density and muscular force can't be seen in neither subjects with high PA level, nor sedentary populations (low PA). In fact, differences are evidenced only in subjects where the level of PA is in accordance with international standards of recommendations for PA (21), not in those with lower PA (group 1: <600 MET-minutes/week) or no PA at all, neither in those with higher PA (group 3: >3000 MET-minutes/week) (15). The mechanism behind this phenomenon remain unknown and further investigation within this field is required, while clinicians should take this fact into consideration when prescribing the DXA scan to their patients.

	PA1 (D vs. ND)	P value	PA2 (D vs. ND)	P value	PA3 (D vs. ND)	P value
BMD	0.422±0.08 vs. 0.412±0.07	p>0.05	0.462±0.09 vs. 0.391±0.06	p<0.05	0.461±0.1 vs. 0.391±0.1	p<0.05
T-score	0.029±1.19 vs. -0.425±0.89	p>0.05	0.267±1.3 vs. -0.622±0.66	p<0.05	0.491±1.21 vs. 0.431±1.68	p>0.05
Z-score	0.427±0.96 vs. -0.05±0.62	p>0.05	0.46±1.32 vs -0.5±0.73	p<0.05	0.813±1.12 vs. 0.873±1.42	p>0.05
HIS	35.04±10.61 vs. 32.88±9.24	p>0.05	42.36±7.69 vs. 37.55±8.63	p>0.05	37.15±8.84 vs. 31.03±8.5	p<0.05

Table 4. Males BMD, T-score, Z-score and HIS based on the PAL (1, 2, 3) between dominant and non-dominant sides. BMD Body Mass Density, PAL Physical Activity Level, HIS Handgrip Isometric Strength

	PA1 (D vs. ND)	P value	PA2 (D vs. ND)	P value	PA3 (D vs. ND)	P value
BMD	0.31±0.05 vs. 0.265±0.02	p<0.05	0.327±0.06 vs. 0.295±0.04	p<0.05	0.362±0.08 vs. 0.345±0.06	p>0.05
T-score	-1.05±1.25 vs. -1.69±0.48	p>0.05	-0.52±1.12 vs. -1.11±0.84	p<0.05	0.214±1.61 vs. -0.165±1.21	p>0.05
Z-score	-0.17±1.45 vs -0.59±0.56	p>0.05	0.098±0.93 vs -0.446±0.67	p<0.05	0.705±1.31 vs. 0.315±0.976	p>0.05
HIS	25.36±2.77 vs 22.28±2.36	p<0.05	24.94±5.59 vs. 22.49±4.43	p<0.05	28.37±6.15 vs. 26.62±6.26	p>0.05

Table 5. Females BMD, T-score, Z-score and HIS based on the PAL (1, 2, 3) between dominant and non-dominant sides. BMD Body Mass Density, PAL Physical Activity Level, HIS Handgrip Isometric Strength, D Dominant, ND Non-Dominant

Our findings demonstrate that side-to-side differences between D and ND distal radial sites present a factor which should be in consideration amongst clinicians, but not in the way it is done right now.

Normally, distal radial DXA scan is performed based on many factors, such as financial matters, availability and accessibility to device, exceeded weight of the subjects (when a distal DXA scan is the only way) etc. and is usually used either as a supportive measurement or when it's the only way of measuring bone density. In these cases, when planning to perform a DXA analysis for clinical diagnosis on distal radial forearm, firstly gender and then an evaluation of physical activity level should be previously considered. We suggest to use self evaluating IPAQ for measuring the level of physical activity (15). Once the subject belongs to group 2 (middle level of PA according to IPAQ), side to side differences between D and ND arms should be considered. This counts for both genders.

We hypothesize that the lack of significant differences in BMD in late adult males (40-65) should be a matter of cultural behavior, especially since in this culture, males traditionally tend to be in charge for the majority of hardworking either at working place or at home, comparing to females. This counts especially regarding the physical performance (e.g. lifting heavy things) that is not expressed in general level of physical activity.

Although this hypothesis is attractive, further future studies are needed to verify the possible correlation of these differences with the cultural behaviors.

Finally, our study has a couple limitations. Firstly, even though the relationship of distal forearm with lumbar spine and femoral neck's bone density has been reported previously (22), our study did not evaluate potential differences in the other bone sites, such as the hips or tibia. Secondly, a greater sample size (perhaps) could have given stronger results.

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- Authors' contributions: EK and ABo made substantial contribution to conception and design of the study, acquisition, analyses and interpreting of data, as well as taking part when performing the measurements. AK performed the measurements and collected data's. ABa and SG were consulted on the statistical analysis and interpretation of data, participated in the drafting and critical revision of the manuscript ensuring that questions related to accuracy or integrity of any part of the work are appropriately investigated and resolved. MK participated in study design, performed a critical revision and made the final approval the manuscript version to be published. EK drafted the manuscript and is the corresponding author. All authors read and approved the final manuscript.

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