Total Body Water and its Relationship to Functional Performance in Individuals with Diagnosed Osteoarthritis

2015

Sara Hanson
University of Central Florida

Find similar works at: https://stars.library.ucf.edu/honortheses1990-2015

University of Central Florida Libraries http://library.ucf.edu

Part of the Sports Sciences Commons

Recommended Citation

https://stars.library.ucf.edu/honortheses1990-2015/1712

This Open Access is brought to you for free and open access by STARS. It has been accepted for inclusion in HIM 1990-2015 by an authorized administrator of STARS. For more information, please contact lee.dotson@ucf.edu.
TOTAL BODY WATER AND ITS RELATIONSHIP TO FUNCTIONAL PERFORMANCE IN INDIVIDUALS WITH DIAGNOSED OSTEOARTHRITIS

by

SARA J. HANSON

A thesis submitted in partial fulfillment of the requirements for the Honors in the Major Program in Sport and Exercise Science in the College of Education and Human Performance and in the Burnett Honors College at the University of Central Florida Orlando, Florida

Spring Term 2015

Thesis Chair: Anna Valdes, Ph.D.
Abstract

This study examines a possible relationship between Total Body Water (TBW) levels, osteoarthritic pain and functional performance in a sample of untrained adults. Participants complete a Western Ontario and McMaster Universities Arthritis Index (WOMAC) questionnaire, TBW is measured using single-frequency bioelectrical impedance (SF-BIA) and strength, balance and physical function are measured by the completion of 7 standardized functional tests. Participants in this study will include adult men and women, age 35 years and older, who have been previously diagnosed with Osteoarthritis (OA) in the hip or knee, or who score 35 or higher on the WOMAC. This study aims to determine if TBW values, specifically its intracellular compartment (ICW), will have a relationship to WOMAC scores and if intracellular water (ICW) will have a positive correlation to participants’ overall performance on balance, strength, and physical function tests. It is hypothesized that the data will show a negative correlation between ICW and WOMAC scores and a positive correlation between ICW and performance on balance, strength and physical function tests. Little research exists on the relationship between TBW and functional performance in older adults; particularly those whose TBW may be affected by inflammatory conditions such as OA. A goal of this study is to contribute to existing research on the relationship between performance and TBW, while providing insight and data on this relationship in an untrained population.
Acknowledgements

I would like to thank my Honors Thesis Committee, specifically Dr. Anna Valdes for taking me under her wing during a time of major change in the middle of my project, Dr. Maren Fragala for setting me up for a successful honors thesis and helping me find the confidence to pursue research and further education, Dr. Sherron Roberts for always being her warm, optimistic self in times of high stress, rooting for me and her many other students non-stop, and Dr. David Fakuda for his support, feedback and patience over this past year. I would like to thank UCF’s Burnett Honors College and Honors in the Major Program for granting me the Honors in the Major Scholarship for my research, which was a huge morale boost during a time of many obstacles.
# Table of Contents

INTRODUCTION ................................................................................................................................. 1

Problem To Be Researched .................................................................................................................. 1

Review of Literature ........................................................................................................................ 2

Homeostatic imbalances as a result of aging ....................................................................................... 3

Unrecognized dehydration in older adults ......................................................................................... 3

Hydration levels and muscular performance ....................................................................................... 4

Reference values and mean values .................................................................................................... 5

TBW measurement techniques and reliability .................................................................................... 5

Rationale ........................................................................................................................................... 7

METHODS ........................................................................................................................................ 8

Subjects ........................................................................................................................................... 8

Instruments ....................................................................................................................................... 8

WOMAC questionnaire ....................................................................................................................... 8

Total body water and intracellular water ......................................................................................... 9

Balance, strength and physical function .......................................................................................... 9

Procedures ....................................................................................................................................... 10

ANALYSIS OF DATA ......................................................................................................................... 12
RESULTS ............................................................................................................................................... 13

DISCUSSION ....................................................................................................................................... 15

APPENDIX A ....................................................................................................................................... 27

APPENDIX B ....................................................................................................................................... 30

APPENDIX C ....................................................................................................................................... 33

APPENDIX D ....................................................................................................................................... 40

REFERENCES ...................................................................................................................................... 42
List of Figures

Figure 1. TBW and WOMAC................................................................. 19
Figure 2. ICW and WOMAC................................................................. 19
Figure 3. TBW and Gait Speed.............................................................. 20
Figure 4. ICW and Gait Speed.............................................................. 20
Figure 5. TBW and Timed Chair Raise ............................................... 21
Figure 6. ICW and Timed Chair Raise ............................................... 21
Figure 7. TBW and Timed Up and Go ............................................... 22
Figure 8. ICW and Timed Up and Go ............................................... 22
Figure 9. TBW and Fast Paced Walk................................................. 23
Figure 10. ICW and Fast Paced Walk................................................. 23
Figure 11. TBW and Handgrip Strength.............................................. 24
Figure 12. ICW and Handgrip Strength.............................................. 24
Figure 13. TBW and Standing Balance .......................................... 25
Figure 14. ICW and Standing Balance .......................................... 25
Figure 15. TBW and Steps................................................................. 26
Figure 16. ICW and Steps................................................................. 26
List of Tables

Table 1. Correlation Coefficient Interpretations .......................................................... 17
Table 2. Strength of Relationship Between TBW/ICW and Tests ................................. 18
Table 3. Participant Characteristics .............................................................................. 18
INTRODUCTION

Problem To Be Researched

The negative effects that hypohydration and dehydration have on health, strength and athletic performance is a reoccurring topic of recent research. Intracellular water (ICW) and extracellular water (ECW) are the two compartments that make up all the body’s fluids, known as total body water (TBW). Significant research suggests a strong relationship between athletic performance and strength and ICW in young, athletically trained populations [11,17,19,20,21]. More research is needed to determine if a relationship between TBW and muscular strength, power and physical performance exists when training circumstances, training status and population are varied. Little research exists on the relationship between TBW and functional performance in older adults, particularly those whose TBW may be affected by inflammatory conditions such as Osteoarthritis (OA). Body water status is a topic of concern in older adults, as a significant number of cases of dehydration go unrecognized in hospitals [6]. With inadequate hydration going unnoticed in a clinical setting, the average adult may also unknowingly suffer consequences of dehydration. To contribute to the aforementioned findings, this study compares TBW levels, osteoarthritic pain and functional performance in a sample of untrained adults.

Participants completed a Western Ontario and McMaster Universities Arthritis Index (WOMAC) questionnaire to evaluate pain, stiffness, and physical functioning in the affected joint after which TBW was measured using single-frequency bioelectrical impedance (SF-BIA). Finally, strength, balance and physical function were measured by the completion of seven standardized functional tests. Participants in this study included adult men and women, age 35 years and older,
who have been previously diagnosed with OA in the hip or knee, or currently score 35 or higher on the WOMAC questionnaire. This study aims to determine if TBW values, specifically its intracellular compartment (ICW), will have a positive correlation to participants’ overall performance on balance, strength, and physical function tests. This study also aims to report hydration levels in comparison to the current American population mean values based on age and gender. Furthermore, this study aims to examine the possibility of a relationship between TBW and ICW levels and the participant’s WOMAC scores. Based on information gathered from studies on performance and hydration across varying populations, it is hypothesized that the data will show a positive correlation between ICW and performance on balance, strength and physical function tests. In addition, it is hypothesized that 20% of participants will fall below the average hydration ranges for the American population. Finally, it is hypothesized that a negative correlation exists between TBW and ICW levels and WOMAC scores.

**Review of Literature**

Water is essential for life and cellular homeostasis, making up about 75% of an infant’s body mass [17] and an average 60% and 51% body mass in adult men and women, respectively [5]. TBW is all the fluid occupying two main compartments, intracellular and extracellular spaces. Intracellular water (ICW) is the sum of all fluids inside cell membranes and makes up about 65% of TBW, while extracellular water (ECW) is all fluid outside the cells, including interstitial fluid and plasma, making up about 35% of TBW [5]. Fluid balance is controlled by homeostatic mechanisms. However, aging causes homeostatic imbalances that contribute to the decline of TBW [1, 8] and an increased susceptibility to OA [18]. OA, one of the leading causes of pain and disability in the world, is largely classified by degradation of articular
cartilage, the tissue covering articulating bones in synovial joints [14,16,18].

**Homeostatic imbalances as a result of aging.**

Older adults are at a higher risk for losses in intracellular and extracellular levels than are young adults. TBW levels are negatively affected by homeostatic imbalances such as impairment of thirst regulation, thermoregulation and reabsorption of water in the urinary system as a result of aging [7]. Monitoring body water levels in older adults may help prevent dehydration, which is defined as a reduction in body mass by 1% or more, solely due to losses of body fluids [5]. Additionally, aging is the highest risk factor in the development of OA [14,18]. Shane et al states that “If the basic cellular mechanisms that maintain tissue homeostasis decline with ageing, then the response to stress or joint injury will not be adequate and joint tissue destruction and loss will be the result [18].” Articular cartilage is composed of two main compartments, chondrocytes and the extracellular matrix. Chondrocytes, or cartilage cells, are responsible for continuous remodeling of the extracellular matrix [16,18]. Water constitutes for 70% of articular cartilage, which is housed within the extracellular matrix [16,18]. The decline in synthesis of chondrocytes and cellular activity, as well as the considerable changes to the extracellular matrix explain the age related increase in roughness, decrease in hydration, and reduction in ability to repair damaged matrix in articular cartilage [16]. Although joint hydration is controlled by specific interactions within chondrocytes and the extracellular matrix, could increasing TBW levels have positive implications in preserving the integrity of cartilage in osteoarthritic joints?

**Unrecognized dehydration in older adults.**

Bennett et al. studied the possibility of dehydration going unrecognized in older adults in hospitals and medical care facilities, finding that 48% of the older adults admitted to the emergency department were dehydrated [7]. Furthermore, of this sample of dehydrated patients,
25% suffered from arthritis or osteoporosis [7]. The researchers found no documentation from nurses on testing for dehydration or clinical signs of dehydration being noted in patient charts [7]. Knowing the clinical signs can be helpful when classifying the type of dehydration, either intracellular or extracellular dehydration. Some clinical signs of intracellular dehydration include mucosal dryness, confusion, and changes in thirst [7]. Clinical signs of extracellular dehydration may include concentrated urine, weight loss, arterial hypotension, or tachycardia [7]. Dehydration can occur in patients in long-term or acute care, increasing the risk of infection and frequently causing morbidity and mortality.

**Hydration levels and muscular performance.**

Several studies conducted on trained athletes have shown that a relationship exists between changes in body water and strength, power and performance [17,19,20,21]. A recent study conducted on national level athletes over the course of their respective sport season, analyzed the relationship between changes in leg strength and jump performance with changes in TBW and its compartments [21]. These researchers found that ICW was the main predictor of performance [21]. In other studies, Judo athletes who significantly reduced ICW while trying to achieve a target competition weight also significantly reduced handgrip strength [15] and upper body power output [19]. While this may be true in athletically trained populations, an in-depth review of current literature suggests that hypohydration, or reduced total body water, influences strength and power enough to be significant only to individuals trying to maximize athletic performance [11]. When discussing the relative importance of reductions to strength and power due to hypohydration, the authors state, “These effects are unlikely to affect the casual resistance exerciser attempting to maintain
health and reduce risk of disease” [11].

Reference values and mean values.

Currently, there are no reference values available as a determinant of “ideal” body water levels. Therefore, athletes, patients or persons of the general population cannot determine whether their body water levels are in an ideal range [19]. However, population averages can be referenced to compare hydration status to other individuals of the same age and sex. The National Health and Nutrition Examination Survey (NHANES) interviews and physically examines about 5,000 Americans each year [2]. Using the data from NHANES III, RJL Systems provides a data set of body composition, hydration and electrical values, specific to age and gender, that is measured using BIA (see Appendix A and B for a comprehensive analysis of American Population Body Composition and Hydration Averages) [2]. With more research, reference values for ideal hydration may become available. In a clinical setting, this could mean a decrease in the amount of cases of undetected dehydration, ultimately decreasing the number of patient fatalities due to dehydration. Increasing ICW levels could potentially help increase muscular function, improving acts of daily living, for hospital patients, residential and community dwelling older adults.

TBW measurement techniques and reliability.

TBW and ECW can be assessed using dilution techniques, such as deuterium oxide dilution (D2O) or bromide dilution [3,19], or using bioelectrical impedance (BIA). ICW is determined by calculating the difference between TBW and ECW measurements \( [\text{ICW}(L)=\text{TBW}(L)-\text{ECW}(L)] \) [3,19,21]. Although D2O is accepted as the gold standard for TBW measurements, it is costly, time consuming and requires fixed equipment [7,10]. Single-frequency BIA is an attractive method because it is inexpensive, portable,
noninvasive and easy to operate [4]. However, BIA results are dependent on standardized methodology, measurement conditions, and appropriate equations for ethnic groups, healthy subjects, subjects with body shape abnormalities and subjects with other conditions altering hydration.

Differences in limb and body position, electrode placement, and electrical interference in the testing environment can alter BIA measurements and should be standardized. Participants being in a fasted or fed state during BIA testing or testing immediately post-exercise significantly affect results. BIA equations are also not transferable from one population to another. As previously stated, population specific equations should be selected for healthy adults, young or elderly adults, obese or underweight individuals or individuals with other body shape abnormalities, individuals with abnormal hydration levels, and ethnic groups [12]. When adjusted for variability in body size and shape, however, BIA measurements of TBW had no significant difference to TBW measurements using D₂O [7,4,9]. Therefore, BIA is not only convenient, but can be a reliable and accurate method for determining TBW and its compartments with a validated BIA equation.

The most common methods of BIA include single-frequency BIA (SF-BIA) and multi-frequency BIA (MF-BIA). Bioelectrical spectroscopy (BIS), segmental BIA, localized BIA, and bioelectrical impedance vector analysis (BIVA) have also been proposed as valid BIA methods. BIA can be used to measure FFM and TBW. Because of the attractiveness of BIA testing, researchers have compared results from the various methods of body composition and body water measurements. Studies have shown that when using BIA to measure TBW, ICW and ECW in healthy and obese individuals, MF-BIA is the most reliable method [13]. Although SF-
BIA has proven most reliable to predict TBW, particularly in a population of healthy, normally hydrated adults, MF-BIA more accurately measures ECW and ICW specifically.

**Rationale**

Studies analyzing TBW and the relationship to strength and performance have only included young, athletically trained participants [17,19,20,21]. Currently, research has yet to identify the effects of body water levels on functional strength in older adults. Homeostatic imbalances and other variables contributing to the decline of TBW levels and the increase in susceptibility of OA in the elderly may contribute to a decline in strength and physical function. Decreases in muscular strength and physical function not only affect the ability to achieve physical fitness or exercise goals, but also the ability to perform acts of daily living. Monitoring body water levels may have positive implications in maintaining or improving muscular strength and function in older adults or adults suffering from OA, as well as implications in the hospital setting to decrease the number of cases of dehydration illness or death.
METHODS

Subjects
Participants were to include 60 men and women, ages 35 years or older, who had been previously diagnosed with OA of the knee or hip or who had a starting WOMAC score of at least 35. Methods of participant recruitment included word of mouth, flyers, newsletters and electronic media outlets. A scripted screening, either over the phone or in person, determined participant eligibility. If a participant was determined to be eligible, they were required to complete an informed consent, which was approved by the Institutional Review Board and were required to be physically cleared for participation by the Physical Activity Readiness Questionnaire, a medical history screening and/or clearance from a physician.

Instruments
WOMAC questionnaire.
The WOMAC Questionnaire is considered a valid method of assessing pain, stiffness and physical function in individuals with OA of the hip and/or knee [9]. The WOMAC consists of 24 questions that are divided into 3 categories; pain (5 questions), stiffness (2 questions) and physical function (17 questions). The questions inquire about pain and stiffness felt, as well as difficulty performing daily activities due to arthritis within the last 48 hours. Participants were to answer each question with one of the following: none (0 points), mild (1 point), moderate (2 points), severe (3 points), and extreme (4 points). After the participant completed the questionnaire, the points from each of the 24 questions were totaled. This number was assigned as participant’s WOMAC score for that given day (see Appendix C for the WOMAC questionnaire used in this study).
Total body water and intracellular water.

TBW and its compartments were measured using the ImpediMed DF50, a single-frequency (50kHz) bioimpedance analyzer. Principals of BIA are explained using a cylinder model. Assuming a uniform cylinder of homogeneous conductive material and uniform cross-sectional area (A) is being measured, the resistance (R) of the material is proportional to its length (L) and inversely proportional to its cross-sectional area (A) \[ \frac{L^2}{R} \] \[12\]. Kyle et al. states that, “an empirical relationship can be established between the impedance quotient (L^2/R) and the volume of water, which contains electrolytes that conduct the electrical current through the body” \[12\]. The body is not a uniform cylinder; therefore, an appropriate coefficient must be added to account for differences in size, shape, and composition of the segments being measured \[12\]. The final equation will be used as a population specific equation to determine TBW and its compartments. SF-BIA is not reliable for cases of extreme BMI ranges or changes in hydration, but has been reported as a valid method to predict TBW in subjects of normal hydration \[13,5\].

Balance, strength and physical function.

Participants performed the Standing Balance Test and the Step Test to demonstrate balance. The Standing Balance Test required participants to stand in a single leg stance for as long as possible. This was performed on the leg affected by OA and the unaffected leg. During the Step Test, participants stood on their leg suffering most from OA and took a step with the opposite foot onto a 15-cm step and back down. Participants were asked to complete as many steps as possible over 15 seconds. The same procedure was then done while standing on the unaffected leg.

Handgrip Strength was measured using a dynamometer in a straight-arm and bent-arm position. During the Bent-arm Handgrip, the arm was positioned by the side of the body and
bent to 90 degrees. The Straight-arm Handgrip was performed with the arm positioned down, straight by the side of the body. Participants were asked to squeeze the device as forcefully as possible for 3 to 5 seconds with each hand. The highest measurement of three attempts was recorded in kilograms (kg).

Physical Function was assessed using the Gait Speed, Timed Chair Raise, Timed Up and Go and Fast Paced Walk Tests. For each of the following physical function tests, time was recorded in seconds (s) using a handheld stopwatch. The Gait Speed Test required participants to walk at their normal walking speed over a straight 40-foot course. For the Timed Chair Raise Test, participants were asked to stand as quickly as possible from a chair, with arms folded across the chest, five consecutive times. The Timed Up and Go Test measured the time it took the participant to stand from a seated position, walk a 10-meter path then return to the seated position in the same chair. Lastly, the Fast Paced Walk Test required participants to complete a 10-meter path four consecutive times, walking as quickly as possible.

**Procedures**

Participants completed the WOMAC questionnaire, BIA analysis, and functional testing, respectively. All participants were asked to refrain from any vigorous activity and alcohol consumption within 24 hours prior to testing. The BIA measurements were taken with the participant in a relaxed, supine position on a padded wooden table and after the participant had remained in this position for 5-10 minutes. Legs were slightly separated and arms abducted from the trunk. A total of 4 electrodes were placed on the right side of the body, 2 placed on the ankle and 2 on the wrist (Appendix D). Each measurement was then averaged from a total of 3 consecutive recordings. When BIA measurements were complete, participants then performed
their Gait Speed, Fast Paced Walk, Timed Chair Raise, Timed Up and Go, Standing Balance, Step, and Straight and Bent-arm Handgrip Strength Tests.
ANALYSIS OF DATA

The relationships between total body water measures (TBW, ICW) and performance (balance, strength, physical function) and the relationship between total body water measures (TBW, ICW) and WOMAC scores for pain, stiffness, and physical function were evaluated using Pearson correlational analyses. A p level of \( \leq 0.05 \) was considered statistically significant. Correlation coefficients were reported as \( r \)-values, and interpreted according to the criteria found in Table 1.

Participant anthropometric, body composition and hydration data, specifically the means and standard deviations of each measure, are recorded in Table 3. The data found in this table was compared to the current American population averages for age and gender [2] (Appendix A and B). Table 2 shows the \( r \)-values and strength of relationship associated with TBW, WOMAC score and functional tests, as well as the \( r \)-values and strength of relationship for ICW, WOMAC and functional tests. In Figures 1-16, scatter plots show the strength of the relationship, if any, between TBW and WOMAC, TBW and each individual functional test, ICW and WOMAC, and ICW and each individual functional test.
RESULTS

It was predicted that ICW and the results of the functional tests would have a positive correlation. After interpreting the r-values, ICW showed a very strong positive relationship to Standing Balance on the OA affected leg (r=0.9; p=0.29) and a weak positive relationship to Standing Balance on the non-affected leg (r=0.2; p=0.87), another very strong positive relationship to Steps on both the OA affected (r=0.9; p=0.29) and the non-affected leg (r=0.8; p=0.41), and a strong positive relationship to Gait Speed (r=0.4; p=0.74). The hypothesis that a positive correlation would be seen between ICW and functional tests only proved true for 3 of the 7 tests. However, these results are not significant at p < 0.05.

Interestingly, where ICW showed negative relationships, TBW showed corresponding positive relationships. A very strong positive relationship to the Up and Go (r=0.9), Fast Paced Walk (r=0.8), Straight-arm Handgrip Strength (r=0.7) and a weak positive relationship to Bent-arm Handgrip Strength (r=0.2) were seen with TBW. Both ICW and TBW showed no relationship to the Chair Raise test with the same r-value (r=0.1). Additionally, ICW had a weak positive relationship on the non-affected leg of the Standing Balance Test (r=0.2) while TBW showed no relationship but had a negative r-value (r=0.1). Similarly, ICW had no relationship to Bent-arm Handgrip Strength with the negative r-value (r=0.1) while TBW showed the same weak positive relationship (r=0.2). (Refer to Table 2 for r-value and p-values).

It was hypothesized that 20% of participants would fall below the average American hydration ranges. It was not possible to measure 20% of participants, however, all participants hydration levels were within ± 5.4 L or % of the average recorded levels for gender and age. One participant measured below the average TBW% (percentage of body weight that is total body
water) and one participant measured below the average ICW% (percentage of total body water that is intracellular water). Lastly, it was hypothesized that TBW and ICW would have a negative relationship to WOMAC score. There was a very strong negative relationship between ICW and WOMAC scores ($r=-0.7$; $p=0.51$), however, TBW and WOMAC scores showed a strong positive relationship ($r=0.6$; $p=0.59$). Neither result were significant at $p \leq 0.05$. (Refer to Table 2 for $r$-values)
DISCUSSION

A purpose of this study was to bring awareness of the importance of proper hydration levels on functional performance in adults, especially those who are untrained and have inflammatory conditions. The functional tests were to represent movements and types of activities in every day living. Potential practical application would include the use of BIA in a health care setting for testing hydration levels and distinguishing dehydration as either intracellular or extracellular to avoid illness or death due to hypohydration or dehydration. Also, if body water levels showed a positive relationship to functional performance or a negative relationship to OA pain, BIA could be used for monitoring TBW in older adults and adults with inflammatory conditions to promote maintaining or improving muscular strength and function.

The sample population in this study included only three of the minimum 60 total participants. Of these three participants, all were female, ages 55, 60, and 71. Two participants were affected by OA of the knee, while one was affected by OA of the hip. This sample of three participants is not a reliable representation of the population to be studied. Testing and BIA measurements were only performed on one day. Body water levels, as well as WOMAC scores can vary from day to day. Therefore, these types of changes may contribute to the participants’ performance on functional testing on that given day. Given a larger set of participants and multiple days of testing and data collection, results would be more reliable.

The hypothesis that ICW will have a positive correlation to functional tests only proved true on the Gait Speed Test, Step Test, and Standing Balance Test. However, the results were not significant at \( p \leq 0.05 \).

It was hypothesized that TBW and ICW would show a negative relationship to WOMAC
score. TBW showed a strong positive relationship to WOMAC, therefore it seems that ICW, because of its strong negative relationship, may have more of an influence on WOMAC score than ICW.

To further examine the possibility that ICW has a stronger influence on WOMAC score, each participant’s body water values were compared to the average American ranges for body water and their respective WOMAC score. Participant 11 measured 0.4% and 0.1% above the American average of TBW% and ICW%, respectively. Participant 11 also had the lowest WOMAC score of a 6. Participant 6 measured 3.2% below the average TBW% and 1.3% above the average ICW% with a WOMAC score of 29. Participant 3 measured 5.4% above the average TBW% but 3.4% below the average ICW% and had the highest WOMAC score of a 51. Although not considered statistically significant, this may further suggest a possible relationship between ICW levels and WOMAC score.

In conclusion, the sample population size leaves much room for further investigation on the influence of TBW compared to ICW on physical function and OA pain in untrained individuals and individuals with diagnosed OA. A review of current literature suggests that ICW is the main predictor of performance [11,21] but that hypohydration may only affect strength and power enough to be significant to trained athletes [11]. However, data collected from this study suggests a possible relationship between ICW and WOMAC scores. Therefore, with a goal to optimize physical function in individuals with OA and those affected by the decline of TBW with age [1,8], it is further hypothesized that with more research, ICW will show a positive correlation to functional performance and a negative correlation to WOMAC score in an untrained adult population with diagnosed osteoarthritis.
### Table 1. Correlation Coefficient Interpretations

<table>
<thead>
<tr>
<th>$r$ –value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>+.70 or higher</td>
<td>Very strong positive relationship</td>
</tr>
<tr>
<td>+.40 to +.69</td>
<td>Strong positive relationship</td>
</tr>
<tr>
<td>+.30 to +.39</td>
<td>Moderate positive relationship</td>
</tr>
<tr>
<td>+.20 to +.29</td>
<td>Weak positive relationship</td>
</tr>
<tr>
<td>+.01 to +.19</td>
<td>No or negligible relationship</td>
</tr>
<tr>
<td>-.01 to -.19</td>
<td>No or negligible relationship</td>
</tr>
<tr>
<td>-.20 to -.29</td>
<td>Weak negative relationship</td>
</tr>
<tr>
<td>-.30 to -.39</td>
<td>Moderate negative relationship</td>
</tr>
<tr>
<td>-.40 to -.69</td>
<td>Strong negative relationship</td>
</tr>
<tr>
<td>-.70 or higher</td>
<td>Very strong negative relationship</td>
</tr>
</tbody>
</table>

Note: $r$-value ranges from -1.0 to +1.0. The closer $r$ is to either -1.0 or +1.0, the stronger the relationship between the two variables.
### Table 2. Strength of Relationship Between TBW/ICW and Tests

<table>
<thead>
<tr>
<th></th>
<th>WOMAC</th>
<th>Gait Speed</th>
<th>Chair Raise</th>
<th>Up &amp; Go</th>
<th>Fast Walk</th>
<th>Handgrip Strength</th>
<th>Standing Balance</th>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBW (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation Coefficient (r)</td>
<td>r=0.6</td>
<td>r=0.6</td>
<td>r=0.1</td>
<td>r=0.9</td>
<td>r=0.8</td>
<td>r=0.2</td>
<td>r=0.7</td>
<td>r=1.0</td>
</tr>
<tr>
<td>P-value</td>
<td>0.59</td>
<td>0.59</td>
<td>0.94</td>
<td>0.29</td>
<td>0.41</td>
<td>0.87</td>
<td>0.51</td>
<td>&lt;0.00001</td>
</tr>
<tr>
<td>ICW (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation Coefficient (r)</td>
<td>r=-0.7</td>
<td>r=0.4</td>
<td>r=-0.1</td>
<td>r=-1.0</td>
<td>r=-0.9</td>
<td>r=0.1</td>
<td>r=-0.6</td>
<td>r=0.9</td>
</tr>
<tr>
<td>P-value</td>
<td>0.51</td>
<td>0.74</td>
<td>0.94</td>
<td>&lt;0.00001</td>
<td>0.29</td>
<td>0.94</td>
<td>0.59</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Note: VS+, Very Strong Positive; S+, Strong Positive; W+, Weak Positive; NR, No Relationship; VS-, Very Strong Negative; S-, Strong Negative; W-, Weak Negative. A p level of < 0.05 was considered statistically significant.

### Table 3. Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 3</td>
<td>71</td>
<td>167.0</td>
<td>62.1</td>
<td>22.3</td>
<td>45.5</td>
<td>73.3</td>
<td>16.6</td>
<td>26.7</td>
<td>32.8</td>
<td>52.8</td>
<td>16.2</td>
<td>49.3</td>
<td>16.6</td>
<td>50.7</td>
</tr>
<tr>
<td>Participant 6</td>
<td>55</td>
<td>155.5</td>
<td>77.4</td>
<td>32.0</td>
<td>45.8</td>
<td>59.1</td>
<td>31.6</td>
<td>40.9</td>
<td>33.0</td>
<td>42.6</td>
<td>17.8</td>
<td>54.1</td>
<td>15.2</td>
<td>45.9</td>
</tr>
<tr>
<td>Participant 11</td>
<td>60</td>
<td>160.0</td>
<td>60.2</td>
<td>24.1</td>
<td>38.8</td>
<td>64.5</td>
<td>21.4</td>
<td>35.5</td>
<td>28.0</td>
<td>46.5</td>
<td>14.8</td>
<td>53.0</td>
<td>13.2</td>
<td>47.0</td>
</tr>
<tr>
<td>Mean</td>
<td>62.0</td>
<td>161.0</td>
<td>66.6</td>
<td>23.5</td>
<td>43.4</td>
<td>65.6</td>
<td>23.2</td>
<td>34.4</td>
<td>31.3</td>
<td>47.3</td>
<td>16.3</td>
<td>52.1</td>
<td>15.0</td>
<td>47.9</td>
</tr>
<tr>
<td>SD</td>
<td>6.7</td>
<td>4.5</td>
<td>7.7</td>
<td>5.3</td>
<td>4.0</td>
<td>7.2</td>
<td>7.7</td>
<td>7.2</td>
<td>2.8</td>
<td>5.1</td>
<td>1.5</td>
<td>2.5</td>
<td>1.7</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Note: SD, standard deviation; BMI, body mass index; FFM, fat free mass; FFM % Wt., percentage of body mass that is fat free mass; FM, fat mass; FM % Wt., percentage of body mass that is fat mass; TBW, total body water; TBW % Wt., percentage of body mass that is total body water; ICW, intracellular water; ICW % TBW, percentage of total body water that is intracellular; ECW, extracellular water; ECW % TBW, percentage of total body water that is extracellular.
Figure 1. TBW and WOMAC

Figure 2. ICW and WOMAC
Figure 3. TBW and Gait Speed

Figure 4. ICW and Gait Speed
Figure 5. TBW and Timed Chair Raise

TBW and Timed Chair Raise

(r = 0.1; p = 0.94)

Figure 6. ICW and Timed Chair Raise

ICW and Timed Chair Raise

(r = 0.1; p = 0.94)
Figure 7. TBW and Timed Up and Go

TBW and Timed Up and Go

(r = 0.9; p = 0.29)

Figure 8. ICW and Timed Up and Go

ICW and Timed Up and Go

(r = -1.0; p < 0.00001)
Figure 9. TBW and Fast Paced Walk

Figure 10. ICW and Fast Paced Walk
Figure 11. TBW and Handgrip Strength

TBW and Hand Grip Strength
Bent-arm \(r=0.2; p=0.87\), Straight-arm \(r=0.7; p=0.51\)

Figure 12. ICW and Handgrip Strength

ICW and Handgrip Strength
Bent-arm \(r=-0.1; p=0.94\), Straight-arm \(r=-0.6; p=0.59\)
Figure 13. TBW and Standing Balance

**TBW and Standing Balance**

OA Affected Leg ($r = -1.0; \ p = \lt 0.00001$), Non-affected Leg ($r = -0.1; \ p = 0.94$)

![Graph showing TBW and Standing Balance](image)

Figure 14. ICW and Standing Balance

**ICW and Standing Balance**

OA Affected Leg ($r = 0.9; \ p = 0.29$), Non-affected Leg ($r = 0.2; \ p = 0.87$)

![Graph showing ICW and Standing Balance](image)
**TBW and Steps**

OA Affected Leg ($r = -0.8; p=0.41$), Non-affected Leg ($r = -0.7; p=0.51$)

![TBW and Steps Graph]

*Figure 15. TBW and Steps*

**ICW and Steps**

OA Affected Leg ($r = 0.9; p=0.29$), Non-affected Leg ($r = 0.8; p=0.41$)

![ICW and Steps Graph]

*Figure 16. ICW and Steps*
APPENDIX A
## APPENDIX A: AMERICAN POPULATION BODY COMPOSITION AND HYDRATION AVERAGES (MALE AGE GROUPS 30-99)

### Male Age Groups 30-39 (n=1383)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>34.3</td>
<td>61.1</td>
<td>75.6</td>
<td>20.5</td>
<td>24.6</td>
<td>45.4</td>
<td>56.2</td>
<td>26.7</td>
<td>59.0</td>
<td>18.7</td>
<td>41.0</td>
</tr>
<tr>
<td>SD</td>
<td>2.8</td>
<td>10.3</td>
<td>6.2</td>
<td>8.7</td>
<td>6.2</td>
<td>7.5</td>
<td>4.8</td>
<td>3.8</td>
<td>1.4</td>
<td>3.7</td>
<td>1.4</td>
</tr>
</tbody>
</table>

### Male Age Groups 40-49 (n=1155)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>43.9</td>
<td>61.9</td>
<td>74.6</td>
<td>21.8</td>
<td>25.4</td>
<td>46.0</td>
<td>55.5</td>
<td>26.9</td>
<td>58.7</td>
<td>19.1</td>
<td>41.3</td>
</tr>
<tr>
<td>SD</td>
<td>2.8</td>
<td>10.2</td>
<td>5.8</td>
<td>8.5</td>
<td>5.8</td>
<td>7.4</td>
<td>4.5</td>
<td>3.7</td>
<td>1.5</td>
<td>3.7</td>
<td>1.5</td>
</tr>
</tbody>
</table>

### Male Age Groups 50-59 (n=792)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>54.4</td>
<td>62.0</td>
<td>74.4</td>
<td>22.1</td>
<td>25.6</td>
<td>46.1</td>
<td>55.3</td>
<td>26.8</td>
<td>58.3</td>
<td>19.3</td>
<td>41.7</td>
</tr>
<tr>
<td>SD</td>
<td>2.8</td>
<td>9.9</td>
<td>5.8</td>
<td>8.3</td>
<td>5.8</td>
<td>7.3</td>
<td>4.6</td>
<td>3.6</td>
<td>1.6</td>
<td>3.7</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Male Age Groups 60-69 (n=1055)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>64.3</td>
<td>59.9</td>
<td>73.9</td>
<td>21.8</td>
<td>26.1</td>
<td>27.4</td>
<td>44.6</td>
<td>55.0</td>
<td>25.9</td>
<td>58.2</td>
<td>18.7</td>
</tr>
<tr>
<td>SD</td>
<td>2.9</td>
<td>9.4</td>
<td>5.8</td>
<td>7.7</td>
<td>5.8</td>
<td>4.4</td>
<td>7.0</td>
<td>4.6</td>
<td>3.5</td>
<td>1.6</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Male Age Groups 70-79 (n=724)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>73.6</td>
<td>57.5</td>
<td>74.7</td>
<td>20.0</td>
<td>25.3</td>
<td>26.4</td>
<td>42.9</td>
<td>55.7</td>
<td>24.7</td>
<td>57.9</td>
<td>18.1</td>
</tr>
<tr>
<td>SD</td>
<td>2.6</td>
<td>9.1</td>
<td>5.8</td>
<td>7.0</td>
<td>5.8</td>
<td>4.2</td>
<td>6.7</td>
<td>4.6</td>
<td>3.3</td>
<td>1.9</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Male Age Groups 80-89 (n=472)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>82.8</td>
<td>54.5</td>
<td>75.6</td>
<td>18.1</td>
<td>24.4</td>
<td>25.2</td>
<td>40.6</td>
<td>56.4</td>
<td>23.3</td>
<td>57.5</td>
<td>17.3</td>
</tr>
<tr>
<td>SD</td>
<td>2.5</td>
<td>8.0</td>
<td>6.1</td>
<td>6.6</td>
<td>6.1</td>
<td>3.8</td>
<td>6.0</td>
<td>4.9</td>
<td>2.9</td>
<td>1.9</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Male Age Groups 90-99 (n=32)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>90.0</td>
<td>50.2</td>
<td>77.8</td>
<td>15.0</td>
<td>22.2</td>
<td>23.3</td>
<td>37.5</td>
<td>58.1</td>
<td>21.6</td>
<td>57.8</td>
<td>15.9</td>
</tr>
<tr>
<td>SD</td>
<td>0.0</td>
<td>8.0</td>
<td>7.2</td>
<td>6.6</td>
<td>7.2</td>
<td>3.6</td>
<td>6.0</td>
<td>6.0</td>
<td>3.0</td>
<td>2.1</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Note: SD, standard deviation; FFM, fat free mass; FFM % Wt., percentage of body mass that is fat free mass; FM, fat mass; FM % Wt., percentage of body mass that is fat mass; BMI, body mass index; TBW, total body water; TBW % Wt., percentage of body mass that is total body water; ICW, intracellular water; ICW % TBW, percentage of total body water that is intracellular; ECW, extracellular water; ECW % TBW, percentage of total body water that is extracellular.
APPENDIX B: AMERICAN POPULATION BODY COMPOSITION AND HYDRATION AVERAGES (FEMALE AGE GROUPS 30-99)

Female Age Groups 30-39 (n=1632)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>34.5</td>
<td>45.1</td>
<td>63.4</td>
<td>27.9</td>
<td>36.6</td>
<td>27.9</td>
<td>33.6</td>
<td>47.3</td>
<td>17.9</td>
<td>53.5</td>
<td>15.7</td>
</tr>
<tr>
<td>SD</td>
<td>2.9</td>
<td>7.4</td>
<td>8.0</td>
<td>13.1</td>
<td>8.0</td>
<td>7.2</td>
<td>5.5</td>
<td>6.1</td>
<td>2.3</td>
<td>2.0</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Female Age Groups 40-49 (n=1248)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>43.8</td>
<td>45.4</td>
<td>62.0</td>
<td>29.3</td>
<td>38.0</td>
<td>28.6</td>
<td>33.8</td>
<td>46.2</td>
<td>17.9</td>
<td>53.2</td>
<td>15.9</td>
</tr>
<tr>
<td>SD</td>
<td>2.8</td>
<td>7.1</td>
<td>6.8</td>
<td>11.7</td>
<td>6.8</td>
<td>6.6</td>
<td>5.4</td>
<td>5.1</td>
<td>2.2</td>
<td>1.9</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Female Age Groups 50-59 (n=907)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>54.3</td>
<td>45.3</td>
<td>61.4</td>
<td>30.1</td>
<td>38.6</td>
<td>29.1</td>
<td>33.8</td>
<td>45.8</td>
<td>17.8</td>
<td>52.8</td>
<td>16.1</td>
</tr>
<tr>
<td>SD</td>
<td>2.8</td>
<td>7.1</td>
<td>7.0</td>
<td>11.8</td>
<td>7.0</td>
<td>6.6</td>
<td>5.4</td>
<td>5.2</td>
<td>2.2</td>
<td>2.0</td>
<td>3.2</td>
</tr>
</tbody>
</table>
### Female Age Groups 60-69 (n=1031)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>64.3</td>
<td>43.4</td>
<td>61.7</td>
<td>38.3</td>
<td>28.4</td>
<td>32.5</td>
<td>46.1</td>
<td>17.1</td>
<td>52.9</td>
<td>15.4</td>
<td>47.1</td>
</tr>
<tr>
<td>SD</td>
<td>2.8</td>
<td>6.5</td>
<td>6.6</td>
<td>10.3</td>
<td>5.9</td>
<td>4.9</td>
<td>2.1</td>
<td>2.0</td>
<td>2.9</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

### Female Age Groups 70-79 (n=817)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>73.9</td>
<td>42.4</td>
<td>63.2</td>
<td>36.8</td>
<td>27.5</td>
<td>31.8</td>
<td>47.4</td>
<td>16.7</td>
<td>52.7</td>
<td>15.1</td>
<td>47.3</td>
</tr>
<tr>
<td>SD</td>
<td>2.8</td>
<td>6.4</td>
<td>6.9</td>
<td>9.6</td>
<td>5.5</td>
<td>4.9</td>
<td>5.3</td>
<td>2.0</td>
<td>2.9</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

### Female Age Groups 80-89 (n=477)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>83.0</td>
<td>39.6</td>
<td>65.0</td>
<td>35.0</td>
<td>25.7</td>
<td>29.8</td>
<td>48.9</td>
<td>15.7</td>
<td>52.9</td>
<td>14.1</td>
<td>47.1</td>
</tr>
<tr>
<td>SD</td>
<td>2.6</td>
<td>5.3</td>
<td>6.9</td>
<td>7.7</td>
<td>4.5</td>
<td>4.1</td>
<td>5.2</td>
<td>1.7</td>
<td>2.0</td>
<td>2.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

### Female Age Groups 90-99 (n=44)

<table>
<thead>
<tr>
<th>Age</th>
<th>FFM (kg)</th>
<th>FFM % Wt.</th>
<th>FM (kg)</th>
<th>FM % Wt.</th>
<th>BMI</th>
<th>TBW (L)</th>
<th>TBW % Wt.</th>
<th>ICW (L)</th>
<th>ICW % TBW</th>
<th>ECW (L)</th>
<th>ECW % TBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>90.0</td>
<td>37.1</td>
<td>69.9</td>
<td>30.1</td>
<td>22.8</td>
<td>28.0</td>
<td>52.6</td>
<td>14.8</td>
<td>53.0</td>
<td>13.2</td>
<td>47.0</td>
</tr>
<tr>
<td>SD</td>
<td>0.0</td>
<td>4.2</td>
<td>7.4</td>
<td>6.1</td>
<td>3.5</td>
<td>3.5</td>
<td>5.8</td>
<td>1.5</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Note: SD, standard deviation; FFM, fat free mass; FFM % Wt., percentage of body mass that is fat free mass; FM, fat mass; FM % Wt., percentage of body mass that is fat mass; BMI, body mass index; TBW, total body water; TBW % Wt., percentage of body mass that is total body water; ICW, intracellular water; ICW % TBW, percentage of total body water that is intracellular; ECW, extracellular water; ECW % TBW, percentage of total body water that is extracellular.
APPENDIX C
APPENDIX C: WOMAC QUESTIONNAIRE

WOMAC Osteoarthritis Index LK3.1 (IK)

INSTRUCTIONS TO PATIENTS

In Sections A, B, and C questions are asked in the following format. Please mark your answers by putting an "X" in one of the boxes.

EXAMPLES:

1. If you put your "X" in the box on the far left as shown below,
   none  mild  moderate  severe  extreme
   [ ]  [ ]  [ ]  [ ] [ ]
   then you are indicating that you feel no pain.

2. If you put your "X" in the box on the far right as shown below,
   none  mild  moderate  severe  extreme
   [ ]  [ ]  [ ] [ ] [ ]
   then you are indicating that you feel extreme pain.

3. Please note:
   a) that the further to the right you place your "X", the more pain you feel.
   b) that the further to the left you place your "X", the less pain you feel.
   c) please do not place your "X" outside any of the boxes.

You will be asked to indicate on this type of scale the amount of pain, stiffness or disability you have felt during the last 48 hours.

Think about your knee to be injected when answering the questions. Indicate the severity of your pain and stiffness and the difficulty you have in doing daily activities that you feel are caused by the arthritis in your knee to be injected.

Your knee to be injected has been identified for you by your health care professional. If you are unsure which knee is to be injected, please ask before completing the questionnaire.

Copyright©2004 Nicholas Bellamy
All Rights Reserved
WOMAC Osteoarthritis Index LK3.1 (IK)

Section A

PAIN

Think about the pain you felt during the last 48 hours caused by the arthritis in your knee to be injected.

(Please mark your answers with an "X").

QUESTION: How much pain have you had . . .

1. when walking on a flat surface?
   none □ mild □ moderate □ severe □ extreme □

2. when going up or down stairs?
   none □ mild □ moderate □ severe □ extreme □

3. at night while in bed? (that is - pain that disturbs your sleep)
   none □ mild □ moderate □ severe □ extreme □

4. while sitting or lying down?
   none □ mild □ moderate □ severe □ extreme □

5. while standing?
   none □ mild □ moderate □ severe □ extreme □
WOMAC Osteoarthritis Index LK3.1 (IK)

Section B

STIFFNESS

Think about the stiffness (not pain) you felt during the last 48 hours caused by the arthritis in your knee to be injected.

Stiffness is a sensation of decreased ease in moving your joint.

(Please mark your answers with an "x").

6. How severe has your stiffness been after you first woke up in the morning?
   - none
   - mild
   - moderate
   - severe
   - extreme

7. How severe has your stiffness been after sitting or lying down or while resting later in the day?
   - none
   - mild
   - moderate
   - severe
   - extreme

Study Coordinator
Use Only
STIFF6

STIFF7

Copyright©2004 Nicholas Bellamy
All Rights Reserved

V3 - English for USA
(at baseline)
WOMAC Osteoarthritis Index LK3.1 (IK)

Section C

DIFFICULTY PERFORMING DAILY ACTIVITIES

Think about the difficulty you had in doing the following daily physical activities during the last 48 hours caused by the arthritis in your knee to be injected. By this we mean your ability to move around and take care of yourself.

(Please mark your answers with an "x").

<table>
<thead>
<tr>
<th>QUESTION: How much difficulty have you had...</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. when going down the stairs?</td>
</tr>
<tr>
<td>none     mild     moderate     severe     extreme</td>
</tr>
<tr>
<td>9. when going up the stairs?</td>
</tr>
<tr>
<td>none     mild     moderate     severe     extreme</td>
</tr>
<tr>
<td>10. when getting up from a sitting position?</td>
</tr>
<tr>
<td>none     mild     moderate     severe     extreme</td>
</tr>
<tr>
<td>11. while standing?</td>
</tr>
<tr>
<td>none     mild     moderate     severe     extreme</td>
</tr>
<tr>
<td>12. when bending to the floor?</td>
</tr>
<tr>
<td>none     mild     moderate     severe     extreme</td>
</tr>
<tr>
<td>13. when walking on a flat surface?</td>
</tr>
<tr>
<td>none     mild     moderate     severe     extreme</td>
</tr>
</tbody>
</table>

Copyright ©2004 Nicholas Bellamy
All Rights Reserved

V3 - English for USA
(st baseline)
WOMAC Osteoarthritis Index LK3.1 (IK)

**DIFFICULTY PERFORMING DAILY ACTIVITIES**

Think about the difficulty you had in doing the following daily physical activities during the last 48 hours caused by the arthritis in your knee to be injected. By this we mean your ability to move around and take care of yourself.

(Please mark your answers with an "X").

<table>
<thead>
<tr>
<th>QUESTION: How much difficulty have you had ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. getting in or out of a car, or getting on or off a bus?</td>
</tr>
<tr>
<td>none □</td>
</tr>
<tr>
<td>15. while going shopping?</td>
</tr>
<tr>
<td>none □</td>
</tr>
<tr>
<td>16. when putting on your socks or panty hose or stockings?</td>
</tr>
<tr>
<td>none □</td>
</tr>
<tr>
<td>17. when getting out of bed?</td>
</tr>
<tr>
<td>none □</td>
</tr>
<tr>
<td>18. when taking off your socks or panty hose or stockings?</td>
</tr>
<tr>
<td>none □</td>
</tr>
<tr>
<td>19. while lying in bed?</td>
</tr>
<tr>
<td>none □</td>
</tr>
</tbody>
</table>

Study Coordinator Use Only

PFTN14 □
PFTN15 □
PFTN16 □
PFTN17 □
PFTN18 □
PFTN19 □
WOMAC Osteoarthritis Index LK3.1 (IK)

DIFFICULTY PERFORMING DAILY ACTIVITIES

Think about the difficulty you had in doing the following daily physical activities during the last 48 hours caused by the arthritis in your knee to be injected. By this we mean your ability to move around and take care of yourself.

(Please mark your answers with an " x ")

<table>
<thead>
<tr>
<th>QUESTION: How much difficulty have you had . . .</th>
</tr>
</thead>
<tbody>
<tr>
<td>20. when getting in or out of the bathtub?</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>☐</td>
</tr>
<tr>
<td>21. while sitting?</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>☐</td>
</tr>
<tr>
<td>22. when getting on or off the toilet?</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>☐</td>
</tr>
<tr>
<td>23. while doing heavy household chores?</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>☐</td>
</tr>
<tr>
<td>24. while doing light household chores?</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>☐</td>
</tr>
</tbody>
</table>
APPENDIX D
APPENDIX D: IMPEDIMED DF50 SF-BIA ELECTRODE PLACEMENT

Photo taken by Sara Hanson

Photo taken by Sara Hanson
REFERENCES


