A NORMATIVE DATABASE OF FUNCTIONAL (SHOULDER) TESTS WITHIN HEALTHY MALE OVERHEAD ATHLETES

Dimitri Audenaert  
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Supervisors: Prof. Dr. Ann Cools, PhD-student Dorien Borms

A dissertation submitted to Ghent University in partial fulfilment of the requirements for the degree of Master

Academic year: 2016 – 2017
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Acknowledgements
After an intensive academic year, it has finally come so far. By writing our acknowledgements we finalize our dissertation. Many people have had their share in accomplishing this thesis. Now we would like this opportunity to express our sincere gratitude for their support and effort.

Firstly, we would like to thank our promotor, Prof. Dr. Ann Cools and co-promotor, PhD-student Dorien Borms for their excellent guidance during this project. Dorien Borms was always available to provide us with her expertise and to give us feedback on our work. A special thanks to the Department of Rehabilitation Sciences and Physiotherapy for letting us use their materials.

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Besides, we would like to thank our parents for the financial means that they had to endow. Lots of transfers had to be made to execute our tests so our parents had to lend us a car.

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Dimitri Audenaert
Jeroen Baele
Joren Christiaens

Ghent, 11 May 2017
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANT</td>
<td>Anterior</td>
</tr>
<tr>
<td>CKCUEST</td>
<td>Closed Kinetic Chain Upper Extremity Stability Test</td>
</tr>
<tr>
<td>ER/IR ratio</td>
<td>External rotation/internal rotation ratio</td>
</tr>
<tr>
<td>GLM-ANOVA</td>
<td>General linear model Analysis of Variance</td>
</tr>
<tr>
<td>HHD</td>
<td>Hand-Held Dynamometer</td>
</tr>
<tr>
<td>ICC</td>
<td>Intraclass correlation coefficient</td>
</tr>
<tr>
<td>IL</td>
<td>Inferolateral</td>
</tr>
<tr>
<td>LLL</td>
<td>Lower limb length</td>
</tr>
<tr>
<td>MED</td>
<td>Medial</td>
</tr>
<tr>
<td>MDC</td>
<td>Minimal detectable change</td>
</tr>
<tr>
<td>NORM</td>
<td>Normalized</td>
</tr>
<tr>
<td>PL</td>
<td>Posterolateral</td>
</tr>
<tr>
<td>PM</td>
<td>Posteromedial</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>SEM</td>
<td>Standard error of measurement</td>
</tr>
<tr>
<td>SIAS</td>
<td>Spina Iliaca Anterior Superior</td>
</tr>
<tr>
<td>SL</td>
<td>Superolateral</td>
</tr>
<tr>
<td>SMBT</td>
<td>Seated Medicine Ball Throw</td>
</tr>
<tr>
<td>ULL</td>
<td>Upper limb length</td>
</tr>
<tr>
<td>YBT-LQ</td>
<td>Y-Balance Test Lower Quarter</td>
</tr>
<tr>
<td>YBT-UQ</td>
<td>Y-Balance Test Upper Quarter</td>
</tr>
</tbody>
</table>
Abstract (EN)

Background
Almost no normative data was available in the literature for the Y-Balance Test Upper Quarter (YBT-UQ), Y-Balance Test Lower Quarter (YBT-LQ), Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), Seated Medicine Ball Throw (SMBT) and the isometric strength test of internal and external rotation with the Hand-Held Dynamometer (HHD). Normative data can be used for return to sport criteria and injury prevention.

Objectives
This cross-sectional study was to conduct science-based guidelines for return to play concerning the included tests within healthy overhead athletes. Therefore, the purpose of the study was to provide a normative database for these tests in a sample of overhead athletes to discuss age, sports and side differences.

Study Design
Cross-sectional study

Method
A total of 106 male healthy overhead athletes between 18 and 50 years old (36 volleyball players, 33 tennis players, 37 handball players; age = 25.3 ± 6.6; height = 183.3 ± 6.5; weight = 79.3 ± 10.1) were included in this study. Functional upper limb performance was assessed using YBT-UQ, SMBT and CKCUEST with addition of YBT-LQ for the lower limb and a HHD was used to measure isometric internal and external shoulder strength. Pearson correlation coefficients and coefficients of determination between the included tests were determined. Analysis of variance (ANOVA, linear mixed models) for repeated measures were used to analyze differences for the included tests between arm dominance, age categories and sports disciplines.

Results
Normative data showed differences for the sports disciplines, age categories and arm dominance. No strong correlations were found between the included tests. No relevant three-way interactions were available, only a few two-way interactions and main effects were present.

Conclusion
This study offers a normative database on the included tests. There are differences present between arm dominance, age categories and sports disciplines. Because no strong correlations were found between the included tests, it can be assumed that these tests are not measuring the same aspect of shoulder functionality. Therefore, it can be useful to do all these tests before return to play and do not take conclusions on one test. Further research is necessary to conduct science-based guidelines or injury prevention or return to play concerning the included shoulder tests.
Abstract (NL)

Achtergrond
In de literatuur zijn bijna geen normatieve data weergegeven voor testen zoals de Y-Balance Test Upper Quarter (YBT-UQ), Y-Balance Test Lower Quarter (YBT-LQ), Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), Seated Medicine Ball Throw (SMBT) en de isometrische spierkrachttest van de interne en externe schouderrotatoren met de Hand-Held Dynamometer (HHD). Normatieve data kan gebruikt worden voor return to play criteria en blessurepreventie.

Doelstellingen
De doelstelling van deze cross-sectionele studie was om wetenschappelijke richtlijnen voor return to play op te stellen met betrekking tot de geïncludeerde testen binnen een populatie van gezonde bovenhandse sporters. De opzet van deze studie was dus om normatieve data te verschaffen voor deze testen in een steekproef van bovenhandse sporters. Zo kan men de verschillen tussen leeftijd, sport en zijde bediscussiëren.

Onderzoeksdesign
Cross-sectioneel onderzoek

Methode
Een totaal van 106 bovenhandse sporters met een leeftijd van 18 tot 50 jaar oud (36 volleybalspelers, 33 tennisspelers, 37 handbalspelers; leeftijd = 25.3 ± 6.6; lengte = 183.3 ± 6.5; gewicht = 79.3 ± 10.1) werden in deze studie geïncludeerd. De prestatie van het bovenste lidmaat werd geëvalueerd aan de hand van YBT-UQ, SMBT en CKCUEST met aansluitend de YBT-LQ voor het onderste lidmaat en de HHD om de isometrische kracht van de interne en externe schouderrotatie te bepalen. De Pearson correlatie coëfficiënten en determinatiecoëfficiënten tussen de geïncludeerde testen werden bepaald. Analyse van variantie (ANOVA, linear mixed models) voor herhaalde metingen werden gebruikt om verschillen te analyseren voor de geïncludeerde testen qua armdominantie, leeftijdsgroepen en sportdisciplines.

Resultaten
In de normatieve data zijn verschillen aantoonbaar voor sport, leeftijd en armdominantie. Geen sterke correlaties zijn gevonden tussen de functionele testen en de isometrische krachtsvariabelen. Geen relevante driewegsinteractie was beschikbaar, slechts enkele tweewegsinteracties en hoofdeffecten waren aanwezig.
Conclusies
Deze studie biedt normgegevens aan voor de geïncludeerde testen. Er zijn verschillen aantoonbaar tussen armdominantie, leeftijdsgroepen en de sportdisciplines. Omdat er geen sterke correlaties zijn aangetoond tussen de functionele testen en de isometrische krachtsvariabelen, kan er gesteld worden dat deze testen elk een ander aspect van de schouderfunctionaliteit meten. Het kan dus aangewezen zijn om al deze testen uit te voeren alvorens een conclusie te trekken omtrent return to play in plaats van zich te baseren op slechts één test. Verder onderzoek is noodzakelijk om wetenschappelijke richtlijnen op te kunnen stellen voor blessurepreventie of return to play criteria met betrekking tot de geïncludeerde testen.

Kernwoorden
Normatieve database, Y-Balance Test, Closed Kinetic Chain Upper Extremity Test, Seated Medicine Ball Throw, Hand-Held Dynamometer

Introduction
The shoulder is likely to be the most used joint in our daily activities and therefore susceptible to develop several injuries. Because of a large range of motion a good stability is necessary to avoid excessive motions which can cause injuries due to chronic stress [1, 2]. Anthropometric measures, player position, skill level, amount of training time, flexibility, asymmetry, prior injury, playing surface and shoe type are known risk factors [3-8]. Overhead throwing is an extreme movement because of the high speeds and use of an excessive range of motion like 150 to 210° of external rotation in the shoulder joint [9, 10]. A good functionality of the shoulder requires an optimal coordination of the scapula, stability and kinetic chain function. The integrity of the rotator cuff and capsular structures must be intact in order to serve a stable center of rotation during the throwing motion [11]. Due to susceptibility of the shoulder joint it is most likely that the shoulder injuries occur in overhead sport activities. Common acute disorders are traumatic luxation, acromioclavicular joint disruption, traumatic tendon ruptures, labral lesions, cartilage defects and fractures and furthermore chronic disorders like bursitis, tendinitis, rotator cuff tears and shoulder impingement [12]. Conservative and post-operative injuries demand an intensive and long-term rehabilitation. In order to return to play, criteria are necessary to objectify rehabilitation goals and assess the functionality of the shoulder. Literature states that competitive athletes are more prone to having a faster come back to sports than recreational athletes [13].

Rationale
Functional shoulder tests are included in the rehabilitation because of their qualitative and quantitative assessment that objectifies a person his task or sport specific movements. Different
functional shoulder tests are presented in the literature. The advantages of these functional tests are that they require little experience, no high budget and no high technology. Moreover, these tests are easily executed and understood by patient and therapist [14]. According to the systematic literature overview by Audenaert, Baele & Christiaens [15] a diversity in methods and outcome data were detected within studies for the different functional shoulder tests. Due to a lack of possibility for comparison between functional shoulder tests, a standardized protocol was established for this study.

In the literature studies of Teyhen et al. [16], Butler et al. [17], Butler et al. [18] and Gorman et al. [19] composite scores of the Y-Balance Test Upper Quarter (YBT-UQ) were presented for the dominant upper limb between 85.7 and 88.3% of the upper limb length (ULL) and between 87.2 and 88.3%ULL for the non-dominant upper limb. In a study of Ali H Alnahdi et al. [20] composite scores were described for the Y-Balance Test Lower Quarter (YBT-LQ) being 94.1% of the lower limb length (LLL) for the dominant leg and 95.3%LLL for the non-dominant leg. Concerning the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), values between 22.00 and 30.41 were reported by Pontillo et al. [21], Roush et al. [22] and Sciascia et al. [23]. No relevant values were found regarding the Seated Medicine Ball Throw (SMBT) due to protocol variation in starting position, weight of the ball and throwing angle. According to the study of Cools et al. [24] there were available values across all athletes and ages in a supine position with 90° of abduction in the shoulder and neutral rotation. Mean values for isometric external rotation of the dominant arm with the Hand-Held Dynamometer (HHD) were 145.2N and 140.3N for the non-dominant arm. Mean values for isometric internal rotation of the dominant arm were 165.4N and 153.2 for the non-dominant arm. In contrary to the study of Cools et al. [24], this cross-sectional study executed the isometric shoulder rotation strength test in 0° abduction and neutral rotation. Overall, there is little availability of normative data of return to play tests in overhead athletes.

In this cross-sectional study the YBT-UQ, YBT-LQ, CKCUEST, SMBT and isometric shoulder rotation strength with the HHD were executed. Solely the YBT-LQ is not directly shoulder related though was implemented to evaluate the kinetic chain. It is most likely that functional performance of the lower limb is related to the performance of upper limb joints due to the influence of the kinetic chain [25, 26]. In this study an overhead sports population of male volleyball, handball and tennis players underwent the included tests mentioned above. The age of the subjects varied between 18 to 50 years old which were classified in three age groups: 18-25y, 26-33y and 34-50y. The comparison was not defined and data of the tests were considered as outcome.
Objectives
No universal accepted tests for return to play are available for the upper limb in contrary to the lower limb where tests as ‘single leg hop test’ could predict injury and provide performance values [27-29]. Reference values of the included tests are essential for physiotherapists and others to define the rehabilitation goals. Until now there are no available normative values for the YBT-UQ, YBT-LQ, CKCUEST, SMBT and isometric shoulder rotation test measured with the HHD in a 0-0 position. What are the reference values of the described included tests? A normative database could be able to determine return to play and to objectify progress. For example, an athlete who underperformed in total could be susceptible for shoulder pathology. Furthermore this player could be assessed by these tests to determine rehabilitation process and ability to return to play. The purpose of this study is to establish a normative database for the included tests in overhead athletes.

Methods
Setting
Test moments took place in the laboratories of Ghent University Hospital or in the sports accommodations of the involved clubs. The recruitment started in July of 2016 and persisted during the testing phase, which began at start of the academic year 2016-2017. Data collection started in February 2017 while the testing phase was still active. The testing phase was finalized at the end of March.

Participants
Inclusion and exclusion criteria were based on the article of Cools et al. [24]. Included subjects were between 18 and 50 years old and were minimal 3 h/week active in volleyball, tennis or handball on a competitive level. Subjects were excluded if they had any history of shoulder sub- or dislocation, orthopedic surgery, systemic diseases or if they experienced pain with time-loss in sports participation the past 6 months. Inclusion and exclusion criteria were assessed with a questionnaire. Sports clubs and individual athletes were contacted by e-mail, mobile phone and in person. An online survey was composed to facilitate the screening of potential participants. After screening for eligibility, practical matters as date, time, participants and location were agreed on. The study sample consisted of 106 male healthy overhead athletes. 10 participants were dominant on the left side and 96 on the right side. The dominance was determined by asking the preferred throwing hand. One hundred subjects were ought to be sufficient for a reliable study in a proportion of at least 33 subjects per sports discipline. Furthermore each sports discipline was initially divided in four groups regarding age: 18-25y, 26-33y, 34-41y and 42-50y. Due to a lack of sufficient
participants within the oldest categories, they were merged into one category of age 34-50 years. A presentation of anthropometric data is summarized in Table 1. Approval for the investigation was received by the Ethical Committee of Ghent University (2016/0963).

**Table 1. Anthropometric data of the study participants**

<table>
<thead>
<tr>
<th>Sport</th>
<th>Age Category</th>
<th>N</th>
<th>Age</th>
<th>Height</th>
<th>Mass</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volleyball</td>
<td>18-25</td>
<td>19</td>
<td>21.8 ± 2.1</td>
<td>184.4 ± 6.9</td>
<td>79.0 ± 7.8</td>
<td>23.3 ± 2.2</td>
</tr>
<tr>
<td></td>
<td>26-33</td>
<td>11</td>
<td>29.2 ± 2.6</td>
<td>186.4 ± 5.9</td>
<td>82.2 ± 9.4</td>
<td>23.7 ± 2.4</td>
</tr>
<tr>
<td></td>
<td>34-50</td>
<td>6</td>
<td>35.7 ± 2.0</td>
<td>184.8 ± 6.3</td>
<td>78.9 ± 11.3</td>
<td>23.1 ± 3.2</td>
</tr>
<tr>
<td></td>
<td>Total, 18-50</td>
<td>36</td>
<td>26.4 ± 5.8</td>
<td>185.1 ± 6.4</td>
<td>80.0 ± 8.8</td>
<td>23.3 ± 2.3</td>
</tr>
<tr>
<td>Tennis</td>
<td>18-25</td>
<td>20</td>
<td>20.2 ± 2.0</td>
<td>181.3 ± 5.2</td>
<td>74.4 ± 10.8</td>
<td>22.6 ± 3.0</td>
</tr>
<tr>
<td></td>
<td>26-33</td>
<td>6</td>
<td>27.0 ± 2.6</td>
<td>184.2 ± 5.9</td>
<td>77.2 ± 4.6</td>
<td>22.8 ± 1.5</td>
</tr>
<tr>
<td></td>
<td>34-50</td>
<td>7</td>
<td>38.3 ± 5.5</td>
<td>177.8 ± 7.1</td>
<td>80.3 ± 9.1</td>
<td>25.4 ± 2.1</td>
</tr>
<tr>
<td></td>
<td>Total, 18-50</td>
<td>33</td>
<td>25.3 ± 7.9</td>
<td>181.1 ± 5.9</td>
<td>76.1 ± 9.7</td>
<td>23.2 ± 2.8</td>
</tr>
<tr>
<td>Handball</td>
<td>18-25</td>
<td>24</td>
<td>20.8 ± 2.6</td>
<td>183.8 ± 6.1</td>
<td>78.4 ± 10.7</td>
<td>23.1 ± 2.4</td>
</tr>
<tr>
<td></td>
<td>26-33</td>
<td>9</td>
<td>27.6 ± 1.4</td>
<td>183.5 ± 8.6</td>
<td>87.3 ± 12.7</td>
<td>26.1 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>34-50</td>
<td>4</td>
<td>37.5 ± 3.7</td>
<td>183.6 ± 7.8</td>
<td>87.0 ± 3.2</td>
<td>25.8 ± 1.4</td>
</tr>
<tr>
<td></td>
<td>Total, 18-50</td>
<td>37</td>
<td>24.3 ± 5.9</td>
<td>183.7 ± 6.7</td>
<td>81.5 ± 11.3</td>
<td>24.1 ± 3.2</td>
</tr>
<tr>
<td>All sports</td>
<td>18-25</td>
<td>63</td>
<td>20.9 ± 2.2</td>
<td>183.2 ± 6.1</td>
<td>77.3 ± 10.0</td>
<td>23.0 ± 2.5</td>
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<tr>
<td></td>
<td>26-33</td>
<td>26</td>
<td>28.1 ± 2.4</td>
<td>184.9 ± 6.8</td>
<td>82.8 ± 10.3</td>
<td>24.3 ± 3.4</td>
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<td></td>
<td>34-50</td>
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<td>37.2 ± 4.1</td>
<td>181.6 ± 7.3</td>
<td>81.4 ± 9.2</td>
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<td></td>
<td>Total, 18-50</td>
<td>106</td>
<td>25.3 ± 6.6</td>
<td>183.3 ± 6.5</td>
<td>79.3 ± 10.1</td>
<td>23.6 ± 2.8</td>
</tr>
</tbody>
</table>

*N number, BMI Body Mass Index*

**Testing procedure**

Prior to participation, the questionnaire was checked for eligibility. If so, subjects read and signed the informed consent form. The participant determined the randomization of the tests by taking five cards with the name of the test on the backside. Anthropometric measurements as weight, height, ULL and LLL were measured before testing. Weight was measured with the same scale for all subjects. Measurement of the ULL happened with a tape measure in standing position reaching from the spinous process of the seventh cervical vertebrae to the most distal point of the middle finger in 90° shoulder abduction, arm fully extended and palm of the hand facing the ventral side. LLL was measured starting from the SIAS reaching to the distal point of the medial malleolus after neutralizing lumbopelvic rotation in supine position. Non-dominant side was primary tested to dominant side for each test. The tests were performed in sports outfit and barefoot.
Materials required to conduct the YBT-UQ were the Y-Balance Test Kit™ (Move2Perform, Evansville, IN), duplex tape and a fitness mat. The duplex tape was necessary to fixate the Y-Balance Test Kit™ on the ground. A fitness mat was used to make the participant comfortable during the rest period. The test was explained and demonstrated by the researchers. The participant had to stand in a three-point plank position (figure 1) with the shoulder perpendicular to the hand and with the feet shoulder-width apart [16-18, 30]. The tested side was named based on the hand providing support during the trial. The thumb of the tested arm was placed as close as possible to the red line without crossing it. The red line was located on the medial side of the stance platform perpendicular to the medial reach direction. The athlete started from this position and reached a reach box successively in the medial (M), inferolateral (IL) and superolateral (SL) direction (figure 1 and 2). The participant had to reach the reach box on the inner side with controlled speed and without kicking it away. It was not allowed to touch the floor or the topside of the reach box. During the test, the body could be adjusted in order to obtain an optimal reach distance as long as the feet and tested upper limb remained still. The test was completed when the participant was able to retain stability by coming back to the starting position. After completion, the reach distance was measured in centimeter up to half a centimeter. Execution of the test was similar to the studies of Butler et al. [17, 18], Gorman et al. [19], Teyhen et al. [16] and Westrick et al. [30]. The participant had two practice trials on each side which had to be performed as good as possible to guarantee an optimal result during the performance trials [16-18]. Standard motivation was applied during the performance. Feedback could be given during and after the practice trials to endeavor a perfect executed test. A rest period of one minute was foreseen after the practice trials. There were three performance trials on each side with a rest period of 30 seconds [16, 19]. The person was instructed to perform as good as possible accounting the received feedback of the researchers. The primary variables for the test contained a mean score for each direction separately for the tested side [16, 19]. To be able to compare the results between the participants, the mean score of each direction was normalized by the ULL [16, 19]. Subsequently, a composite score for each limb was calculated as a secondary...
variable in percentage by an addition of the average reach values of the three directions, divided by three times the ULL [30].

**YBT-LQ**

Materials required to conduct the YBT-LQ were the Y-Balance Test Kit™ (Move2Perform, Evansville, IN) and duplex tape. The duplex tape was necessary to fixate the Y-Balance Test Kit™ on the ground. The test was explained and demonstrated by the researchers. The participant had to adapt a single lower limb stance on the stance platform box, which was the tested side. The top of the hallux had to be behind the red line. The red line was located on the anterior side of the immovable central box, perpendicular to the anterior reach direction. In contrast to the YBT-UQ, the YBT-LQ had to be completed for the non-dominant and dominant side in one direction before testing the next direction instead of all directions in one trial. Reaching directions were respectively anterior (A), posteromedial (PM) and posterolateral (PL) (figure 3, 5). The participant had to reach the reach box on the inner side with controlled speed and without kicking it away. It was not allowed to touch the floor or the topside of the reach box. During the test, the body could be adjusted in order to obtain an optimal reach distance as long as the heel stayed on the stance platform (figure 4). The test was completed when the participant was able to retain stability by coming back to the starting position. After completion, the reach distance was measured in centimeter up to half a centimeter. Execution of the test was similar to the study of Kang et al [31]. The participant had two practice trials on each side for a specific direction. This was repeated for every direction before starting the performance trials. Practice trials, motivation, feedback, rest periods between practice and performance trials were applied identically as the YBT-UQ except no rest period was applied between performance trials. The participants executed three performance trials [16, 20, 31]. The primary variables for the test contained a mean score for each direction separately for the tested side [16, 31]. To be able to compare the results between the participants, the mean score of each direction
was normalized by the LLL [16, 20, 31]. Subsequently, a composite score for each limb was calculated as a secondary variable in percentage by an addition of the average reach values of the three directions, divided by three times the LLL [20].

CKCUEST
Materials required to conduct the CKCUEST were two strokes of white tape of 3.8cm, a fitness mat and a stopwatch. There had to be a distance of 91.4cm between the two strokes of white tape [14, 21-23, 32-34]. The test was explained and demonstrated by the researchers [34, 35]. An initial push-up position (figure 6) with the middle fingers on the tape strokes, feet placed shoulder width apart and the shoulders perpendicular to the hands was assumed. A straight back had to be maintained during the test [14, 21-23, 32-36]. A fitness mat could be placed underneath the knees for comfort. The number of the touches was counted out loud and was considered as a standard motivation during the performance. Feedback could be given during and after the familiarization trial to endeavor a perfect executed test. By the sign of the researcher, the subject brought his dominant hand to his non-dominant hand that was stabilizing at the moment, followed by replacing his dominant hand to the starting position. Subsequently the non-dominant hand acted in an identical way. This alternating technique was continued for 15 seconds wherein the participant tried to accomplish as many touches as possible [14, 21-23, 32-36]. One researcher counted the number of touches and another researcher took care of the timing [33, 35]. When one researcher said ‘stop’, both researchers focused on the last real touch to decide whether it was in time or not. Both researchers were aware of possible errors such as not touching the hand, not placing the hand on the tape, bending the knees on the ground and failing to maintain feet on the ground or a straight back. There was one submaximal familiarization trial and four performance trials. Unable to touch the hand, as it should be, was not counted as one tap. If one of the other errors of above were present, the test was immediately ejected and a rest period was given to prepare for a new trial. At the start of the performance trials, the participants had been told to execute the test as good as possible. A rest period of 45 seconds was present between the performance trials [22, 36]. A mean score was calculated of the three performance trials [33, 36]. No normalization was applied on the values.

Figure 6. CKCUEST initial push-up position
SMBT

Materials required to conduct the SMBT were a 2kg medicine ball [37, 38], a 10m tape measure, chalk powder and a sweeping brush. Chalk powder was necessary to leave a print behind on the floor to determine the throwing distance. The 10m tape measure had to start from a stable wall where the participant was able to sit down. The test was explained and demonstrated by the researchers. The participant had to sit down with their hips as close to the wall as possible. The back, shoulders and head had to make full contact with the wall all the time [37, 39, 40]. The legs had to be extended and closed (figure 7). To allow for different arm length between participants, the ball was dropped with extended arms and horizontally in front of the subject when the legs were abducted. The distance between the wall and the most proximal point, indicated by the chalk powder, was subtracted from the total throwing distance. This distance was considered as the zero mark. The medicine ball was in both hands with the arms in 90° abduction and full elbow flexion. After permission of the researcher, the subject had to throw the medicine ball in a horizontal line as far as possible. Presence of a reviewer within a throw lane of 10m was not allowed to avoid that the subject would withhold his throw. If the back, shoulders or head lost contact with the wall or if the medicine ball was thrown in a deviating angle instead of a horizontal line, the test was invalid and needed to be re-done [39, 40]. There were three practice trials after instruction and demonstration. It was important that the subject delivered maximum performance to guarantee an optimal result of the performance trials. The researchers were using standardized instructions and verbal cues. Feedback could be given during and after the practice trials to endeavor a perfect executed test. There was a rest period of two minutes after the practice trials. Afterwards there were four performance trials and a rest period of one minute was given after each performance trial. After each performance trial, the researcher noted the throwing distance to one centimeter accurately. This was the distance between the wall and the most proximal point indicated by the chalk powder. Afterwards, the chalk powder had to be removed by a sweeping brush to be ready for the next trial. The mean score for the SMBT was calculated by dividing all adapted throwing distances in cm by the four performance trials [38, 40-48]. Note that the original throwing distance was adapted by subtracting the zero mark distance to eliminate influence of the arm length.

Figure 7. SMBT starting position
Materials required to conduct this test were MicroFET\textsuperscript{©} HHD and a treatment table. The test was explained and the researcher showed the shoulder movements. Before testing, the subject made a standardized warming-up of ten times a swinging movement to shoulder abduction-adduction, ten times a swinging movement to shoulder anteflexion-retroflexion and ten push-ups against the wall [24]. After the warming-up, the subject was lying supine on the treatment table [49]. The researcher gave information about the internal and external rotators muscles of the arm by showing an internal and external rotation movement of the arm. The purpose of this device was also explained to the subjects. The researcher took the arm of the subject and made an internal and external movement as kind of a demo. The position that had to be maintained during the test was a supine position with the legs extended, feet and hips on the treatment table without losing full contact, opposite hand under the pelvis to avoid compensation, elbow against the trunk with an elbow flexion of 90\textdegree, dorsum of the hand pointed laterally and hand and fingers relaxed (figure 8,9). During the test, the force had to be build-up slowly within the first two seconds to reach the maximal force for the following five seconds [24, 49]. It was important that the participant and the researcher dropped the force and lost contact at the same time, if not, errors could occur. The researcher held the HHD 2cm under the styloid process which was marked with a pencil (for internal rotation on the palmar side and for external rotation on the dorsal side) [24]. The test must be an isometric make test. The hand of the participant was fixated between the chest of the researcher and the hand that held the HHD. The elbow was fixated against the trunk of the subject for external rotation [50]. The results were measured up to 0.1 Newton approximately. This test was repeated three times for each muscle group of one side with a rest period of 20 seconds between the performance trials. If there was a difference of 20\% between the trials of a muscle group on a specific side, a fourth trial was necessary. The mean score of the three valid performance trials was calculated for the HHD test. Normalization was applied by dividing the mean score to the body weight.
Statistical methods
Means and standard deviations were calculated for all dependent variables as YBT-UQ (cm) including medial, inferolateral and superolateral direction, YBT-LQ (cm) including anterior, posteromedial and posterolateral direction, CKCUEST (number of touches), SMBT (cm) and isometric shoulder strength test with the HHD (Newton) performed on the dominant and non-dominant side across the participants. Intraclass correlation coefficients (ICC [3,k]) over the performance trials of each test were calculated to assess trial-to-trial reliability. Standard error of the measurement (SEM) and the minimal detectable change (MDC) was calculated to examine absolute reliability. Since the data was normally distributed, confirmed by the Shapiro-Wilk test, parametric tests were applied. The Levene’s test showed a normal distribution of variance. Finally the Mauchly’s test for sphericity validated the use of repeated measures analysis of variance (ANOVA). Pearson correlation coefficient ($r$) was used to assess possible relationships between the variables tests. Correlations ($r$) were categorized weak ($\leq 0.499$), moderate ($0.50 – 0.707$) or strong ($\geq 0.707$). A coefficient of determination ($R^2$) was used to explore the amount of variability in the variables of the tests.

A general linear model for three-way ANOVA for repeated measures was used to analyze differences between the tests. Side (two levels) was used as within-subject factor and sports discipline (three levels) and age category (three levels) were used as between-subject factors. Initially three-way interactions were assessed and in case of no interaction two-way interactions between the involved variables were examined. If there were still no interactions assessed, main effects for side, sports discipline, or age category were examined. Alpha was set on $0.05$ for the significance. When performing post hoc analyses a Bonferroni procedure were applied when a significant difference was found. Statistical analyses were completed by using the IBM SPSS Statistics, version 21 (IBM Corporation, Armonk, NY, USA).

Results
Reference values are divided by sports discipline and age category. Mean normalized scores for the medial, inferolateral, and superolateral directions and composite scores of the YBT-UQ are provided in Table 2. The medial reach direction scored higher than the inferolateral reach direction followed by the superolateral reach direction. Mean normalized scores for the anterior, posteromedial, and posterolateral directions and composite scores of the YBT-LQ are foreseen in Table 3. Posteromedial reach direction scored higher than the posterolateral reach direction followed by the anterior direction. Internal rotation showed higher scores than external rotation for these reference values. Mean normalized scores for the SMBT and mean scores for the CKCUEST are
present in Table 4. Mean normalized scores for the internal and external isometric strength test of the HDD and ER/IR ratio are summarized in Table 5.
### Table 2. Descriptive analysis of the results of the normative and composite scores of the YBT-UQ

<table>
<thead>
<tr>
<th>Sport</th>
<th>Age Category</th>
<th>YBT-UQ MED ND NORM</th>
<th>YBT-UQ IL ND NORM</th>
<th>YBT-UQ SL ND NORM</th>
<th>YBT-UQ ND COMP</th>
<th>YBT-UQ MED D NORM</th>
<th>YBT-UQ IL D NORM</th>
<th>YBT-UQ SL D NORM</th>
<th>YBT-UQ D COMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volleyball</td>
<td>18-25y</td>
<td>104.67 ± 5.08</td>
<td>93.3 ± 10.4</td>
<td>73.1 ± 11.5</td>
<td>90.35 ± 7.04</td>
<td>104.21 ± 5.30</td>
<td>93.65 ± 12.93</td>
<td>72.14 ± 9.58</td>
<td>90.00 ± 7.48</td>
</tr>
<tr>
<td></td>
<td>26-33y</td>
<td>102.21 ± 2.74</td>
<td>95.17 ± 11.22</td>
<td>72.16 ± 8.91</td>
<td>89.85 ± 5.71</td>
<td>101.12 ± 3.62</td>
<td>95.19 ± 10.20</td>
<td>73.34 ± 7.40</td>
<td>89.89 ± 5.27</td>
</tr>
<tr>
<td></td>
<td>34-50y</td>
<td>102.83 ± 4.46</td>
<td>91.71 ± 10.34</td>
<td>66.23 ± 8.50</td>
<td>86.93 ± 4.77</td>
<td>100.39 ± 2.15</td>
<td>90.84 ± 7.80</td>
<td>65.58 ± 11.95</td>
<td>85.60 ± 2.21</td>
</tr>
<tr>
<td>Tennis</td>
<td>18-25y</td>
<td>102.88 ± 5.73</td>
<td>93.76 ± 10.25</td>
<td>68.23 ± 7.22</td>
<td>88.27 ± 6.22</td>
<td>103.45 ± 5.87</td>
<td>90.55 ± 10.46</td>
<td>68.95 ± 8.88</td>
<td>87.65 ± 5.62</td>
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<td>26-33y</td>
<td>104.73 ± 13.39</td>
<td>102.01 ± 7.03</td>
<td>82.67 ± 15.38</td>
<td>94.75 ± 8.47</td>
<td>105.17 ± 8.16</td>
<td>95.12 ± 10.68</td>
<td>75.64 ± 10.51</td>
<td>91.83 ± 5.73</td>
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<tr>
<td></td>
<td>34-50y</td>
<td>100.29 ± 9.35</td>
<td>91.43 ± 10.74</td>
<td>67.92 ± 11.86</td>
<td>86.55 ± 9.40</td>
<td>103.77 ± 9.72</td>
<td>84.94 ± 11.94</td>
<td>63.86 ± 12.26</td>
<td>84.19 ± 10.23</td>
</tr>
<tr>
<td>Handball</td>
<td>18-25y</td>
<td>104.20 ± 5.46</td>
<td>93.72 ± 12.14</td>
<td>71.44 ± 10.81</td>
<td>89.79 ± 7.38</td>
<td>101.96 ± 5.92</td>
<td>91.38 ± 12.63</td>
<td>70.96 ± 11.33</td>
<td>87.82 ± 8.22</td>
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<td></td>
<td>26-33y</td>
<td>106.59 ± 4.70</td>
<td>97.22 ± 10.51</td>
<td>67.37 ± 12.90</td>
<td>90.40 ± 7.46</td>
<td>107.21 ± 8.30</td>
<td>91.67 ± 6.83</td>
<td>64.22 ± 10.93</td>
<td>87.70 ± 7.82</td>
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<tr>
<td></td>
<td>34-50y</td>
<td>111.02 ± 7.75</td>
<td>102.60 ± 6.98</td>
<td>77.35 ± 7.95</td>
<td>96.99 ± 7.23</td>
<td>111.47 ± 7.72</td>
<td>103.12 ± 7.87</td>
<td>72.72 ± 9.03</td>
<td>95.77 ± 7.68</td>
</tr>
</tbody>
</table>


### Table 3. Descriptive analysis of the results of the normative and composite scores of the YBT-LQ

<table>
<thead>
<tr>
<th>Sport</th>
<th>Age Category</th>
<th>YBT-LQ ANT ND NORM</th>
<th>YBT-LQ PM ND NORM</th>
<th>YBT-LQ PL ND NORM</th>
<th>YBT-LQ ND COMP</th>
<th>YBT-LQ ANT D NORM</th>
<th>YBT-LQ PM D NORM</th>
<th>YBT-LQ PL D NORM</th>
<th>YBT-LQ D COMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volleyball</td>
<td>18-25y</td>
<td>58.78 ± 5.19</td>
<td>101.11 ± 7.37</td>
<td>106.60 ± 6.54</td>
<td>91.83 ± 4.69</td>
<td>58.61 ± 4.67</td>
<td>112.12 ± 8.63</td>
<td>108.42 ± 6.38</td>
<td>93.05 ± 5.35</td>
</tr>
<tr>
<td></td>
<td>26-33y</td>
<td>60.26 ± 6.82</td>
<td>106.11 ± 10.91</td>
<td>±103.68 ± 9.20</td>
<td>90.02 ± 8.11</td>
<td>57.80 ± 5.62</td>
<td>107.68 ± 6.71</td>
<td>108.08 ± 8.52</td>
<td>91.19 ± 6.17</td>
</tr>
<tr>
<td></td>
<td>34-50y</td>
<td>61.17 ± 4.47</td>
<td>103.98 ± 9.36</td>
<td>±97.81 ± 8.35</td>
<td>87.66 ± 6.95</td>
<td>56.61 ± 7.48</td>
<td>100.94 ± 7.97</td>
<td>95.90 ± 7.99</td>
<td>84.48 ± 6.55</td>
</tr>
<tr>
<td>Tennis</td>
<td>18-25y</td>
<td>58.86 ± 5.15</td>
<td>105.78 ± 8.04</td>
<td>105.04 ± 8.82</td>
<td>89.89 ± 5.98</td>
<td>58.82 ± 5.73</td>
<td>107.08 ± 7.11</td>
<td>107.76 ± 7.11</td>
<td>91.22 ± 5.71</td>
</tr>
<tr>
<td></td>
<td>26-33y</td>
<td>61.08 ± 6.68</td>
<td>109.23 ± 8.84</td>
<td>107.06 ± 4.15</td>
<td>92.46 ± 5.10</td>
<td>61.21 ± 8.53</td>
<td>106.14 ± 12.06</td>
<td>106.16 ± 6.29</td>
<td>91.17 ± 6.91</td>
</tr>
<tr>
<td></td>
<td>34-50y</td>
<td>55.50 ± 6.23</td>
<td>100.49 ± 9.98</td>
<td>100.90 ± 9.49</td>
<td>85.63 ± 5.77</td>
<td>57.55 ± 6.72</td>
<td>105.09 ± 9.17</td>
<td>102.79 ± 9.31</td>
<td>88.48 ± 6.73</td>
</tr>
<tr>
<td>Handball</td>
<td>18-25y</td>
<td>56.80 ± 4.43</td>
<td>104.44 ± 6.38</td>
<td>101.05 ± 6.89</td>
<td>87.53 ± 4.24</td>
<td>55.17 ± 5.08</td>
<td>102.78 ± 8.06</td>
<td>101.76 ± 6.96</td>
<td>86.78 ± 4.65</td>
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<tr>
<td></td>
<td>26-33y</td>
<td>57.98 ± 5.69</td>
<td>106.58 ± 6.10</td>
<td>105.10 ± 11.37</td>
<td>89.88 ± 6.96</td>
<td>57.41 ± 4.58</td>
<td>106.65 ± 10.10</td>
<td>107.31 ± 10.09</td>
<td>90.46 ± 7.08</td>
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<td>34-50y</td>
<td>58.43 ± 2.68</td>
<td>108.74 ± 7.39</td>
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<td>57.45 ± 5.85</td>
<td>104.25 ± 9.71</td>
<td>103.96 ± 6.36</td>
<td>88.55 ± 5.00</td>
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</table>

Table 4. Descriptive analysis of the results of the normative scores of the SMBT and mean scores of CKCUEST

<table>
<thead>
<tr>
<th>Sport</th>
<th>Age Category</th>
<th>SMBT MEAN</th>
<th>CKCUEST MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volleyball</td>
<td>18-25y</td>
<td>311.33 ± 40.66</td>
<td>27.72 ± 3.68</td>
</tr>
<tr>
<td></td>
<td>26-33y</td>
<td>298.09 ± 22.99</td>
<td>27.42 ± 2.53</td>
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<tr>
<td></td>
<td>34-50y</td>
<td>306.21 ± 37.58</td>
<td>26.06 ± 1.82</td>
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<tr>
<td>Tennis</td>
<td>18-25y</td>
<td>296.30 ± 38.80</td>
<td>27.63 ± 2.32</td>
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<td></td>
<td>26-33y</td>
<td>307.08 ± 21.61</td>
<td>28.06 ± 3.73</td>
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<td></td>
<td>34-50y</td>
<td>316.82 ± 50.07</td>
<td>25.10 ± 1.18</td>
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<tr>
<td>Handball</td>
<td>18-25y</td>
<td>306.17 ± 36.15</td>
<td>27.87 ± 2.59</td>
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<tr>
<td></td>
<td>26-33y</td>
<td>346.78 ± 46.67</td>
<td>27.00 ± 2.42</td>
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<tr>
<td></td>
<td>34-50y</td>
<td>298.19 ± 55.43</td>
<td>27.42 ± 2.51</td>
</tr>
</tbody>
</table>

NORM normalized values

Table 5. Descriptive analysis of the results of the normative and ratio values of the HHD

<table>
<thead>
<tr>
<th>Sport</th>
<th>Age Category</th>
<th>HHD IR ND NORM</th>
<th>HHD ER ND NORM</th>
<th>HHD ND RATIO</th>
<th>HHD IR D NORM</th>
<th>HHD ER D NORM</th>
<th>HHD D RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volleyball</td>
<td>18-25y</td>
<td>2.58 ± 0.58</td>
<td>1.91 ± 0.21</td>
<td>76.14 ± 11.83</td>
<td>2.71 ± 0.44</td>
<td>1.94 ± 0.29</td>
<td>72.10 ± 8.84</td>
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<td></td>
<td>26-33y</td>
<td>2.33 ± 0.46</td>
<td>1.76 ± 0.30</td>
<td>77.11 ± 15.19</td>
<td>2.61 ± 0.42</td>
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<td>2.03 ± 0.32</td>
<td>1.63 ± 0.27</td>
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<td>2.39 ± 0.39</td>
<td>1.73 ± 0.49</td>
<td>71.42 ± 11.53</td>
</tr>
<tr>
<td>Tennis</td>
<td>18-25y</td>
<td>2.58 ± 0.53</td>
<td>1.93 ± 0.32</td>
<td>76.63 ± 13.10</td>
<td>2.94 ± 0.61</td>
<td>2.05 ± 0.30</td>
<td>71.64 ± 13.19</td>
</tr>
<tr>
<td></td>
<td>26-33y</td>
<td>2.25 ± 0.30</td>
<td>1.76 ± 0.17</td>
<td>78.67 ± 4.89</td>
<td>2.38 ± 0.58</td>
<td>1.86 ± 0.31</td>
<td>80.33 ± 12.79</td>
</tr>
<tr>
<td></td>
<td>34-50y</td>
<td>2.53 ± 0.43</td>
<td>1.89 ± 0.34</td>
<td>75.05 ± 5.95</td>
<td>2.97 ± 0.51</td>
<td>1.93 ± 0.32</td>
<td>65.42 ± 9.67</td>
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<tr>
<td>Handball</td>
<td>18-25y</td>
<td>2.33 ± 0.47</td>
<td>1.79 ± 0.30</td>
<td>78.70 ± 14.67</td>
<td>2.54 ± 0.52</td>
<td>1.85 ± 0.27</td>
<td>74.74 ± 12.97</td>
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<td></td>
<td>26-33y</td>
<td>2.49 ± 0.56</td>
<td>2.01 ± 0.42</td>
<td>82.50 ± 17.11</td>
<td>2.77 ± 0.69</td>
<td>2.04 ± 0.63</td>
<td>74.85 ± 21.36</td>
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<tr>
<td></td>
<td>34-50y</td>
<td>2.55 ± 0.42</td>
<td>1.91 ± 0.41</td>
<td>75.43 ± 11.53</td>
<td>2.70 ± 0.76</td>
<td>1.88 ± 0.62</td>
<td>70.89 ± 16.79</td>
</tr>
</tbody>
</table>

NORM normalized values, ND non-dominant side, D dominant side, IR internal rotation, ER external rotation
The average measures ICC (3,k) for the 5 tests ranged between 0.874 and 0.979, which confirms the good-to-excellent reliability of these tests. The values for the SD, SEM and MDC are summarized in Table 6.

**Table 6. ICC, SD, SEM and MDC of the included tests**

<table>
<thead>
<tr>
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<th>ICC</th>
<th>SD</th>
<th>SEM</th>
<th>MDC</th>
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<td>D MED</td>
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<tr>
<td>SL</td>
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<tr>
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<tr>
<td>SL</td>
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<td>PM</td>
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<td>1.788</td>
<td>4.956</td>
</tr>
<tr>
<td>PL</td>
<td>0.947</td>
<td>7.976</td>
<td>1.836</td>
<td>5.090</td>
</tr>
<tr>
<td><strong>HHD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D IR</td>
<td>0.975</td>
<td>43.294</td>
<td>6.845</td>
<td>18.974</td>
</tr>
<tr>
<td>ER</td>
<td>0.966</td>
<td>26.420</td>
<td>4.872</td>
<td>13.504</td>
</tr>
<tr>
<td>ND IR</td>
<td>0.979</td>
<td>41.871</td>
<td>6.068</td>
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</tr>
<tr>
<td>ER</td>
<td>0.967</td>
<td>23.762</td>
<td>4.317</td>
<td>11.965</td>
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<tr>
<td><strong>SMBT</strong></td>
<td>0.881</td>
<td>39.439</td>
<td>13.605</td>
<td>37.711</td>
</tr>
<tr>
<td><strong>CKCUEST</strong></td>
<td>0.927</td>
<td>2.735</td>
<td>0.739</td>
<td>2.048</td>
</tr>
</tbody>
</table>


Correlation Coefficients, Coefficient of Determination and Difference (P Values) between the tests are shown in the attachments. Generally, independent of the side for the isometric strength tests with the HHD correlated to the other tests resulted in significant correlations with the composite score for the YBT-UQ (r range = 0.189-0.228; P < 0.035) and the YBT-LQ (r range = 0.215-0.353; P < 0.028). Only the non-dominant side for both internal and external rotation had a significant weak correlation with the SMBT (r = 0.233 and 0.198 respectively; P < 0.017 and P < 0.043 respectively). Significant correlations were weak for the internal and external rotation of the non-dominant side and the internal rotation of the dominant side to the CKCUEST (r range = 0.243-0.318; P < 0.012). The non-significant correlations were weak for the isometric strength tests compared to the other
Tests. Correlations between the isometric strength test variables itself were all significant, including a strong correlation for the external and internal rotation comparing the dominant and non-dominant side \( (r = 0.796; P = 0 \text{ and } r = 0.781; P = 0) \) with a coefficient of determination of 0.634 and 0.610 respectively. Also a moderate correlation of 0.634 was found for the ER/IR ratio comparing the dominant and non-dominant side \( (P = 0) \) and a weak to moderate correlation \( (r \text{ range } = 0.440-0.607; P = 0) \) was found for the other comparisons between the HHD. Weak correlations were found for the SMBT compared to YBT-UQ, YBT-LQ and CKCUEST, although they were not significant. Concerning the CKCUEST, only a significant weak correlation was found with the composite score of the dominant side of the YBT-UQ. The correlation was weak and not significant for the non-dominant side. The CKCUEST showed a weak correlation with the composite scores of the YBT-LQ of both sides but were not significant. Only a significant correlation \( (r \text{ range } = 0.227-0.309; P < 0.02) \) was present for the posteromedial direction of the dominant side and for posteromedial and posterolateral direction of the non-dominant side. Correlations between other directions were also weak but not significant. Correlations between the YBT-UQ and the YBT-LQ were all significant including a weak correlation \( (r \text{ range } = 0.335-0.435) \) between the composite score of the YBT-UQ compared to the YBT-LQ for the dominant side as well as for the non-dominant side of each test. At last, a strong correlation was found between the composite score for the dominant and non-dominant limb of the YBT-UQ and YBT-LQ \( (r = 0.812; P = 0 \text{ and } r = 0.815; P = 0 \text{ respectively}) \) with a coefficient of determination of 0.659 and 0.664 respectively.

The results of the ANOVA for repeated measures statistical analysis and the post hoc tests are summarized in Table 7. The YBT-UQ showed age and sports discipline differences with significantly higher composite scores for handball players compared to tennis players in the oldest age category. All age categories of the handball and tennis players scored significantly higher for the non-dominant side compared to the dominant side. Concerning the handball players, the medial direction scored significantly higher in the oldest age category compared to the youngest age category. Within the oldest age category, the handball players scored significantly higher on the medial direction compared to the other sports. The medial direction was significantly higher on the dominant side for the handball players compared to the dominant side of volleyball players and also the non-dominant side of the handball players was higher compared to the non-dominant side of tennis players. The inferolateral direction scored significantly higher on the non-dominant side compared to the dominant side in all sports categories in the youngest and the middle age category, plus this was also the case for the oldest category in tennis players. The superolateral direction scored significantly higher on the dominant side compared to the non-dominant side for handball players. The YBT-LQ showed age and sports discipline differences with significantly higher
composite scores in the youngest age category of volleyball players when compared to their oldest age category. Within the youngest age category, the volleyball players scored significantly higher than the handball players. The anterior direction scored significantly higher on the non-dominant side compared to the dominant side for all age categories of the volleyball players. The youngest age category of volleyball players scored significantly higher than the oldest age category for the posterolateral direction. A three-way interaction was present for the posteromedial direction. The isometric internal rotation strength testing showed age and sides differences with significantly higher scores for the dominant side in every age category. There were also sports discipline and side differences with significantly higher scores for the dominant side in every sports discipline. The isometric external rotation strength showed age and side differences with significantly higher scores for the dominant side in the youngest and middle age category. Only in every age category of volleyball players was their dominant side significantly higher than their non-dominant side. No interactions or main effects were found for the SMBT and CKCUEST.
Table 7. Results from the GLM ANOVA for repeated measures and post hoc tests for all variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>YBT-UQ COMP</th>
<th>MED NORM</th>
<th>IL NORM</th>
<th>SL NORM</th>
<th>YBT-LQ COMP</th>
<th>ANT NORM</th>
<th>PM NORM</th>
<th>PL NORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-way interaction</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Two-way interaction</td>
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<td></td>
</tr>
<tr>
<td>Side x sport</td>
<td>H*: H &gt; V</td>
<td>T*: ND &gt; D</td>
<td>H*: D &gt; ND</td>
<td>NS</td>
<td>V*: ND &gt; D</td>
<td>NS</td>
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<td></td>
</tr>
<tr>
<td>Side x age category</td>
<td>NS</td>
<td>A*, B+: ND &gt; D</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sport x age category</td>
<td>C*: H &gt; T</td>
<td>H*: C &gt; A</td>
<td>NS</td>
<td>NS</td>
<td>V*: A &gt; C</td>
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<tr>
<td></td>
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<td>A*: V &gt; H</td>
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<tr>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td>NA</td>
<td>NA</td>
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<tr>
<td>Side</td>
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<tr>
<td>Sport</td>
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<tr>
<td>Age category</td>
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</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>HHD IR NORM</th>
<th>HHD ER NORM</th>
<th>SMBT NORM</th>
<th>CKCUEST MEAN</th>
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<td>Three-way interaction</td>
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</tr>
<tr>
<td>Side x sport</td>
<td>H*, T*, V*: D &gt; ND</td>
<td>V*: D &gt; ND</td>
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</tr>
<tr>
<td>Side x age category</td>
<td>A*, B*: D &gt; ND</td>
<td>A*: D &gt; ND</td>
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<tr>
<td>Sport x age category</td>
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<td>Main Effects</td>
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</tr>
<tr>
<td>Sport</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Age category</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS not significant, NA not applicable, H handball, T tennis, V volleyball, > higher values, NORM normalized values, COMP normalized composite scores, ND non-dominant side, D dominant side, A [18-25] age category, B [26-33] age category, C [34-50] age category, MED medial, IL inferolateral, SL superolateral, ANT anterior, PM posteromedial, PL posterolateral, IR internal rotation, ER external rotation
* p < 0.001; • p < 0.01; °p < 0.05
Discussion

Summary of evidence

This study was the first to have examined reference values of the included five tests. The main outcome of this study were the normative data of the five tests divided by three sports and three age categories. There was a good-to-excellent trial-to-trial reliability for all these tests. There were only significant two-way interaction effects and strong interlimb correlations for the YBT-UQ, YBT-LQ, and isometric internal and external strength test of the HHD. No strong correlations were found for all the other variables of the included tests.

YBT-UQ

Normative values of the two studies of Butler et al. [17, 18] in male college swimmers and high school baseball players respectively were $100 \pm 8.8\%\text{ULL}$ and $99.1 \pm 8.6\%\text{ULL}$ for the medial direction, $89.8 \pm 10.8\%\text{ULL}$ and $90.3 \pm 11.5\%\text{ULL}$ for the inferolateral direction, $74.9 \pm 9.7\%\text{ULL}$ and $70.4 \pm 11.1\%\text{ULL}$ for the superolateral direction and $88.3 \pm 8.9\%\text{ULL}$ and $86.6 \pm 8.1\%\text{ULL}$ for the composite score. These reference values are in line with the scores of our study. The medial direction was defined as the highest mean value followed by the inferolateral direction and the superolateral direction, which is in line with previous studies [17-19, 30].

Previous studies [17-19, 30] found no significant differences for the specific directions and the composite scores between the dominant and non-dominant upper limb in respectively male overhead athletes, baseball players, active adults and college students while diverging results were present for arm dominance in sports and age categories in our study. Since there were significant differences present for dominance of arm, the non-injured arm cannot be used as a reference for the injured arm while Westrick et al. [30] identified the opposite.

Teyhen et al. [16] concluded that age had no influence on the performance, this is in contrast to our study where the YBT-UQ showed age and sports discipline differences for the medial and composite score. Note that only a few number of older handball players were tested in comparison with the number of younger handball players hence an outlier could have more influence on the total results which could lead to a higher susceptibility in change of results.

In contrast to Westrick et al. [30], which found a significant weak correlation for both limbs between YBT-UQ and CKCUEST, only a significant weak correlation was found for the dominant side of the YBT-UQ with the CKCUEST in our study. The lack of correlation between the YBT-UQ and the other included tests is probably due to the closed chain performance of the YBT-UQ, whereas the other included tests were performed in an open kinetic chain, except for the CKCUEST. More specifically,
it has been shown that shoulder isometric [30] or isokinetic [51] rotation strength is not related to the YBT-UQ, suggesting that other variables within the kinetic chain or important for YBT-UQ performance.

**YBT-LQ**
Normative values for the composite score presented in previous studies were 98.3 ± 8.9%LLL for a military population [16], 103.0 ± 8.0%LLL for high school basketball players [52] and 94.7 ± 7.0%LLL for young healthy adults [20]. Reference values in our study were lower than in the previous mentioned studies. This is in line with previous publications which demonstrated differences on performance on the YBT-LQ by sports, gender and competition level [53]. Because of sports specific characteristics, differences could be present between the different sports. In this study, no differentiation was made between competition levels, they only had to be active in a competition. This can be a possible explanation for diverging values.

The study of Alnahdi et al. [20] concludes that comparison of the injured leg to the non-injured leg is possible in young healthy adults, except for the posteromedial direction because in this direction the non-dominant side scored significantly higher compared to the dominant side. In contrary to our study, a comparison of the injured leg to the non-injured leg is possible for all directions in all sports, except for the anterior direction for volleyball players because the non-dominant side scored significantly higher compared to the dominant side in this sports discipline. No specific reason can be assumed why volleyball players performed better for the anterior direction than other sports disciplines. Teyhen et al. [16] concluded that age had no influence on the performance, this is in contrast to our study where the YBT-LQ showed age and sports discipline differences. Due to a three-way-interaction of the posteromedial direction, a value can be predicted if at least two out of three variables are known. Teyhen et al. [16] found a significant moderate correlation between the YBT-LQ and YBT-UQ, this is in contrast to our study where there was a significant weak correlation.

**CKCUEST**
Normative data of the CKCUEST in previous studies were 22.5 ± 4.3 touches in division I collegiate football players [21] and 30.41 ± 3.87 touches in collegiate baseball players [22]. In our study, the mean result lay in between with a range of 25.10-28.06 touches, achieved over all age categories and sports. A differentiation in population could explain the variability in results.

The CKCUEST required a combination of shoulder stability but foremost a lot of explosive power which can clarify no high correlation with other tests. The SMBT required more explosive power than stability, on the other hand, the YBT tests required more stability than explosivity. This could
clarify that no high correlations were found between the CKCUEST and the other included tests.

In our study, a weak correlation was present between the CKCUEST and the isometric strength test while in other studies there was a high correlation between the CKCUEST and the peak torque of isokinetic internal/external rotation [54]. As already mentioned, difference in type of contraction (isokinetic vs. isometric) could be the reason for these divergent findings.

Note that more volleyball and tennis players of age category [25-33y] and [34-50y] were tested compared to the number of tested handball players. Therefore a worse performance was noticed in general for volleyball and tennis players due to older ages. Also a few handball players (n=4) participated of the last age category [35-50y], which could lead to a higher susceptibility for change in results.

**SMBT**

Comparison of results of this study to other studies was difficult because of differences in ball weights, populations and position of throwing. A mean throwing distance of 347.77 ± 76.79 cm was found in a study of Borms et al. [51] in a population of 14 male and 15 female throwing athletes. The protocol was the same as in this study, although female throwing athletes were included. A mean throwing distance of 308.32 ± 39.44 cm was measured in our study. A possible explanation for the higher results in the study of Borms et al. [51] could be the difference in competition level and sample selection bias.

Recently a new variant of the MBT was published in a study by M. Sayers & S. Bishop [55]. This test was called the Medicine Ball Push-Press (MBP-P) where subjects had to throw the medicine ball straight perpendicular in supine position. The advantage of this test was that it is easier for the subjects to throw in a straight vertical line instead of throwing in a horizontal line. For the SMBT, subjects were triggered to perform as good as possible and due to this, their throw often deviated from the horizontal line. When they would have to throw as high as possible for the MBP-P, they would be obligated to throw in a straight vertical line, otherwise their throw would be lower. The disadvantages of this test were the dysfunctional position and the prices of the high technology cameras to determine the power, velocity, acceleration and maximal force.

The SMBT showed weak correlations with the included tests, only the correlations with the isometric strength test variables were significant. In contrary to our study, a study by Borms et al. [51] showed that the SMBT was moderately to strongly correlated with isokinetic tests for strength of the elbow flexors and extensors and shoulder internal and external rotation. An explanation for these contrary results was likely to be that Borms et al. [51] utilized an isokinetic dynamometer
(model 4; Biodex Medical Systems Inc, Shirley, NY) to determine the rotational strength in contrast to our study where the rotational strength was measured manually with a HHD applying an isometric make-test.

**HHD**

At present, no representative data was available in the literature which studied isometric internal rotation and external rotation in a 0° abduction and 0° ER position of the upper limb (0-0 position) in a supine position.

Mean results of all overhead athletes in the study of Cools et al. [24] for the internal rotation strength were 2.1N/kg for the dominant and 1.9N/kg for the non-dominant side, external rotation strength for both dominant and non-dominant side were 1.8N/kg. In our study where a 0-0 position was applied in contrary to the 90-0 position in Cools et al. [24], the range was 2.38-2.97N/kg for internal rotation and 1.63-2.05N/kg for external rotation. This sets that the internal rotation rotator strength could be better in a 0-0 position compared to a 90-0 position. Cools et al. [24] calculated the ER/IR ratio with 89% for the dominant side and 93% for the non-dominant side. In our study, a range of 65-80% for the dominant side and 75-83% for the non-dominant side was calculated between the different sports disciplines. A lower ratio was determined due to the difference in position. A lower ratio is normal due to the 0-0 position where a norm value is 75% while the norm value for the 90-0 position is 90-100%.

A moderate correlation was found for the ratios of the dominant side compared to non-dominant side meaning that in several cases an interlimb difference was present due to a disbalance between external and internal rotation strength. This is in contrary to the YBT tests and the isometric strength test where a high correlation was calculated between the dominant and non-dominant sides. Current studies have shown that the throwing movement initiates greater gains in internal rotation muscles while external rotation muscle strength remains the same which indicates a disturbed lower ER/IR ratio [56] likewise in our study where the dominant side had a lower ratio compared to the non-dominant side.

**Limitations**

First, different overhead sports disciplines were included which could have influenced the results because of sport specific characteristics. Second, athletes older than 26 years old were difficult to recruit because of the strict inclusion criteria. Older participants are more susceptible for injuries the last six months and for history of orthopedic surgery, there were also few older than younger athletes on a competitive level. Third, the results of the tests are dependent of the intrinsic motivation of the test person, nevertheless a standardized motivation was applied for every test to
maximize the performances. Besides, three investigators were part of this research therefore variance in administering and supervising during the testing was possible. Therefore, to diminish the effect of possible bias, the investigators were instructed and trained to apply a standardized protocol. Also the sitting height (SIAS to ball height) was not measured and taken into account regarding normalization for SMBT. CKCUEST and SMBT were performed bilaterally with the consequence that no side-to-side differences could be examined. Furthermore, in contrast to all other included tests, the CKCUEST was not normalized despite that shoulder width and arm length had an influence on the number of touches. At last, in a study of Kang et al. [31] were ankle dorsiflexion and hip flexion indicated as the best predictors of respectively the anterior and posterior reaches. The predictive values were increased by the addition of counterbalanced trunk kinematics. This findings were similar to the findings of Hoch et al. [57] in the Star Excursion Balance Test (SEBT). Measuring dorsiflexion range of motion, as flexibility, could help future studies to differentiate the amount of influence on stability that is part of the final functionality of the lower limb.

Conclusion
This study offers a normative database on functional tests and isometric internal and external shoulder rotation strength in three age categories and three sports for male overhead athletes. There are differences present between the three sports and age categories. Because no strong correlations were found between the functional tests and the isometric strength variables, it can be assumed that these tests are not measuring the same aspect of shoulder functionality. Therefore, it can be useful to do all these tests before return to play and do not take conclusions on one test. Further research is necessary to conduct science-based guidelines or injury prevention or return to play concerning the included shoulder tests.
References


Abstract (NL) - lekentaal

Achtergrond
In de literatuur zijn bijna geen normgegevens weergegeven voor testen zoals de Y-Balance Test Upper Quarter (YBT-UQ), Y-Balance Test Lower Quarter (YBT-LQ), Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), Seated Medicine Ball Throw (SMBT) en de spierkrachttesten van inwendige en uitwendige schouderrotatoren zonder verandering in spierlengte met de Hand-Held Dynamometer (HHD). Normwaarden kunnen gebruikt worden voor sporthervattingscriteria en blessurepreventie.

Doelstelling
De doelstelling van deze cross-sectionele studie was om wetenschappelijke richtlijnen voor sporthervatting op te stellen met betrekking tot de geïncludeerde testen binnen een populatie van gezonde bovenhandse sporters. De opzet van deze studie was dus om normwaarden te verschaffen voor deze testen in een steekproef van bovenhandse sporters. Zo kan men de verschillen tussen leeftijd, sport en zijde bediscussiëren.

Onderzoeksdesign
Cross-sectioneel onderzoek. Hierbij wordt ieder individu in een groep eenmaal en op hetzelfde tijdstip geobserveerd of gemeten.

Methode
Een totaal van 106 bovenhandse sporters met een leeftijd van 18 tot 50 jaar oud (36 volleybal spelers, 33 tennis spelers, 37 handbal spelers; leeftijd = 25.3 ± 6.6; lengte = 183.3 ± 6.5cm; gewicht = 79.3 ± 10.1kg) werden in deze studie geïncludeerd. De prestatie van het bovenste lidmaat werd geëvalueerd aan de hand van YBT-UQ, SMBT en CKCUEST met aansluitend de YBT-LQ voor het onderste lidmaat en de HHD om de kracht zonder spierlengteverandering van de inwendige en uitwendige schouderrotatie te bepalen. De Pearson correlatie coëfficiënten en determinatiecoëfficiënten tussen de geïncludeerde testen werden bepaald. Analyse van variantie (ANOVA, linear mixed models) voor herhaalde metingen werd gebruikt om verschillen te analyseren voor de geïncludeerde testen qua armdominantie, leeftijdsgroepen en sportdisciplines.

Resultaten
In de normatieve data zijn verschillen aantoonbaar voor sport, leeftijd en zijde. Geen sterke correlaties zijn gevonden tussen de functionele testen en de isometrische krachtsvariabelen. Geen relevante driewegsinteractie was beschikbaar, slechts enkele tweewegsinteracties en hoofdeffecten waren aanwezig.

Conclusies
Deze studie biedt normatieve data aan voor functionele testen en isometrische interne en externe
schouderrotatiekracht. Er zijn verschillen aantoonbaar tussen dominante en niet-dominante zijde, leeftijdscategoriën en de sportdisciplines. Omdat er geen sterke correlaties zijn aangetoond tussen de functionele testen en de isometrische krachtsvariabelen, kan er gesteld worden dat deze testen elk een ander aspect van de schouderfunctionaliteit meten. Het kan dus aangewezen zijn om al deze testen uit te voeren alvorens een conclusie te trekken omtrent sporthervattingscriteria in plaats van zich te baseren op slechts één test. Verder onderzoek is noodzakelijk om wetenschappelijke richtlijnen te kunnen opstellen voor blessurepreventie of sporthervattingscriteria met betrekking tot de geïncludeerde testen.

Kernwoorden
Normatieve database, Y-Balance Test, Closed Kinetic Chain Upper Extremity Test, Seated Medicine Ball Throw, Hand-Held Dynamometer
Proof of submission ethical commission
Betreft
Advies voor mono-centrische studie met als titel:
Onderzoek naar het opstellen van een normatieve database voor functionele schooltesten bij bovenhandse sporters - Scriptie Jeroen Basle
Belgisch Registratienummer: 1670201620983
- Adviesaanvraagformulier dd. 23/08/2016 (volledig ontvangen dd. 23/08/2016)
- (pro)lezen informatie-en toestemmingsformulier da. 1/07/2015
- Vragenlijsten
- Ontwerp
- In- en exclusiecriteriën
- Flyer voor reclutering
- Adviesaanvraagformulier du. 1/10/2016, (Document 2)
- Begeleidingsbrief dd. 13/10/2016
- Informatie- en toestemmingsvormgeving over de verwerking van informatie voor medisch-wetenschappelijk onderzoek dd. 13/06/2016 - Jeroen Basle

Advies werd gevraagd door:
Prof. dr. A. COOLES ; hoofdonderzoeker

BOVENVERMELDE DOCUMENTEN WORDEN DOOR HET ETHICS COMMITTEE BEoordeld.
ER WERD EEN POSITIEVE ADVIES GEESTIVAAL AMIDT PROTOCOL OP 25/10/2016. INDIEN DE STUDIE NIET WORDT OPGESTART VOOR
25/10/2017, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INGEHOUDEN WORDEN.
Voorzitter het onderzoek te starten diert (object) te worden jeugdmeen met Bimeta Clinica (09/932 06 00).

1/02
ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE.
A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 25/10/2016. IN CASE THIS STUDY IS NOT STARTED BY 25/10/2017, THIS ADVIS
WILL NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.
Before initiating the study please contact Bimeta Clinica (09/932 06 00).

DIT ADVIES WORDT OORDEELD IN HET VERSLAG VAN DE VERGADERING VAN HET ETHICS COMMITTEE VAN 15/11/2016.

1/02

- Het Ethicis Comité werkt volgens 'ICH Good Clinical Practice' - regels
- Het Ethicis Comité bekleedt dat een positief advies niet betekent dat het Comité de verantwoordelijkheid voor het onderzoek op zich neemt. Bovendien werkt U er bij te maken dat uw heng te toestemden onderzoekers wordt opnieuw gegeven in publicaties rapporten voor de overheid om., die het resultaat zijn van dit onderzoek.
- In het kader van 'Good Clinical Practice' moet de voegelijkheid bestaan dat het farmaceutisch bedrijf en de autoriteiten waarbij krijgen van de originele data. In dit verband dienen de onderzoekers vooral te werken in dit gebeurt zonder schending van de privacy van de proefpersonen.
- Het Ethicis Comité benadrukt dat het de promote is de verantwoordelijkheid voor de ondervorming en toestemmingsformulieren met de nederlifdelijke documenten.
- Geen enkel onderzoekelijke betrokken bij deze studie lad van het Ethicis Comité.
- Alle leden van het Ethicis Comité hebben dit project beoordeeld. (De ledenlijst is bijgevoegd)
- The Ethics Committee is organized and operates according to the 'ICH Good Clinical Practice' rules.
- The Ethics Committee stresses that approval of a study does not mean that the Committee accepts responsibility for it. Moreover, please keep in mind that your opinion as investigator is presented in the publication, reports to the government, etc. that are a result of this research.
- In the framework of 'Good Clinical Practice', the pharmaceutical company and the authorities have the right to inspect the original data. The investigations have to assure that the privacy of the subjects is respected.
- The Ethics Committee stresses that it is the responsibility of the promoter to guarantee the conformity of the non-dutch informed consent forms with the acht document.
- None of the investigators involved in the study is a member of the Ethics Committee.
- All members of the Ethics Committee have reviewed this project. (The list of the members is enclosed)

Namens het Ethicis Comité/ On behalf of the Ethics Committee

Prof. Dr. D. MATTHYS
Voorzitter/ Chairman

C/c De heer T. VERSCHOORE - Uz Gent - Bimeta Clinica
FAGG - Research & Development, Victor Horlappen 40, postbus 49 1060 Brussel

Universitair Ziekenhuis Gent
De Pintelaan 185 B 9000 Gent
www.uzgent.be
Advisie voor een monocentrische studie met als titel:
Ontwikkeling van een normatieve database voor functionele schoudertesten bij bovenhandse sporters - Scriptie Joren Christiaens
Belgisch Registratienummer: BE701623994
* Adviesaanvraagformulier dd. 22/04/2016 (volledig re观光en dd. 23/06/2016)
* (Patiënten)informatie- en toestemmingssformulier dd. 1/07/2015
* Vragenlijsten
* Doornemen
* - (In-) en exclusiecriteria
* Fiscale voor de research
* Adviesaanvraagformulier dd. 13/10/2016 (document 4)
* Begeleidingsbrief dd. 13/10/2016
* Informatie- en waarschuwingstextus over de verwerking van informatie voor medisch-wetenschappelijk onderzoek dd. 13/06/2016 - Joren Christiaens

Advisie werd gevraagd door:
Prof. dr. A. COOLS; Hoofdonderzoeker

ADVIESVERNEELDE DOCUMENTEN WERDEN DOOR HET ETHICS COMMITTEE BEREIDEN, ER WERD EEN POSITIEF ADVIES GEGROND OP DIT PROTOCOL OP 26/10/2016 INDEN DE STUDIE NIET WORDT OPGESTART VOOR 26/10/2016, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INDIENDE WORDEN.

Voordat het onderzoek te starten dienen dient (iets) te worden gemaakt met Binnete Clinics 08/322 05 08.

THE ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE.

A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 26/10/2016, IN CASE THIS STUDY IS NOT STARTED BY 26/10/2016, THIS ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.

Before initiating the study, please contact Binnete Clinics (08/322 05 08).

DIT ADVIES WORDT OPGEZOMEN IN HET VERSLAG VAN DE VERGADERING VAN HET ETHICS COMMITTEE VAN 26/11/2016


* Het Ethical Comité bekleedt het dat een geraad advies niet bekleedt dat het Comité de verslaggeving deel de onderzoeker op zich nam. Bovendien liet U er over te wezen dat U uw advies als berichten onderzoeker wordt weergegeven in publicaties, rapporten voor de overheid enz., van de resultaten zijn van dit onderzoek.
* In het kader van 'Good Clinical Practice' moet de mogelijkheid bestaan dat het vennootschap bedrijf en de autoriteiten in hoge kracht van de orgaans deelnemen. Dit verband dienen (iets) te worden gemaakt dat dit gebeurt zonder schending van de privacy van de proefpersonen.
* Het Ethical Comité benadrukt dat het de promotor deels van de deelnemers in de conformiteit van de onderlinge informatie- en toestemmingssformulieren met de medische en ethische verplichtingen, de ethische en wetenscappelijke belangen van de proefpersonen, en eventuele onderzoekers die bij deze studie in het Ethical Comité.
* Alle licenties van de Ethical Comité hebben dit project beoordeeld. De leden zijn bij de verhandeling. De Ethical Comité is degenen die de studie gegeven van de ethische en wetenscappelijke belangen van de proefpersonen.
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ETHISCH COMITE
Universitair Ziekenhuis
De Pintelaan 185
9000 Gent
ethisch.comite@UGent.be
tel. +32 9 332 33 36 - +32 9 3320 68 54 - +32 9 332 26 88
fax +32 9 332 49 62

DOCUMENT E (scripties – Z-lijn)

VERZOEK TOT ADVIES VAN HET ETHISCH COMITE BETREFFENDE EEN prospectief observationeel ONDERZOEKSPROJECT OP GEZONDHEIDSGEGEvens voor het maken van scripties en Z-lijn als deel van een reeds goedgedeurde akademisch onderzoek
(enkel verzameling van patientengegevens, vragenlijsten en interviews)

Dit document moet maar 1x ingediend worden indien de scriptie of Z-lijn kadert in een eerder goedgekeurde akademische studie van de promotor (staflid UZ Gent of U Gent).

De studenten moeten eerst contact opnemen met Prof.dr. R. Rubens voor verdere inlichtingen robert.rubens@UGent.be.

Wanneer de scriptie of Z-lijn niet verbonden is aan een globaal academisch onderzoek, maar enkel opgezet is voor de scriptiestudent, dan moet de indiening gebeuren via de standaardprocedure (document D)

1. TITEL VAN HET ONDERZOEK:

ONDERZOEK NAAR HET OPSTELLEN VAN EEN NORMATIEVE DATABASE VOOR FUNCTIONELE SCHOUDERESTEN BIJ BOVENHANDSE SPORTERS

2. PROJECTNUMMER (EC), NAAM AANVRAGER VAN HET REEDS INGEDIENDE AKADEMISCH ONDERZOEK + DATUM GOEDKEURING:
   - PROJECTNUMMER: 2016/0963
   - NAAM ONDERZOEKER: ANN COOLS
   - DATUM GOEDKEURING: 13/9/2016

3. ONDERZOEK IN FUNCTIE VAN:
   - BACHELOR SCRIPTIE
   - NAAM STUDENT(EN):
   - OPLEIDING:
   - NAAM HOGESCHOOL:
   - EMAIL STUDENT:
   - TEL. STUDENT:
   - MASTERScriptIES OF Z-LIJN
   - NAAM STUDENT(EN): AUDENAERT DIMITRI
   - OPLEIDING: MASTER IN REVALIDATIEWETENSCHAPPEN EN KINESITHERAPIE
   - NAAM FACULTEIT: GENEESKUNDE
   - EMAIL STUDENT: DIMITRI.AUDENAERT@UGENT.BE
   - TEL. STUDENT: 0475265446

VERZIE 19-09-2011
4. SOORT ONDERZOEK

- VERZAMELEN VAN PATIËNTENGEGEVENS, DIE KLINISCH STANDAARD GEGEVEN ZIJN (WEZEEN ENKEL AANVULLEN ONDERZOEK, BLOED- OF ANDERE STAALAFNAMEN)
- VRAGENLIJSTEN
- INTERVIEW

5. TAAK VAN DE STUDENT BIJ DIT ONDERZOEK:

BEGELEIDEN VAN DE TESTMOMENTEN, VERZAMELEN VAN PATIËNTENGEGEVENS EN AFINEMEN VAN VRAGENLIJSTEN

6. GEGEvens VAN DE Promotor + AFFILIATIE:

- NAAM: PROF. DR. ANN COOLS
- FUNCTIE: ZAP
- UZ DIENST: OF FACULTEIT/VAKGROEP: GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN, REVALIDATIEWETENSCHAPPEN EN KINESITHERAPIE
- TELEFOONNUMMER: +329 332 26 33
- FAX: +329 332 39 11
- E-MAIL: ANN.COOLS@UGENT.BE
- NAAM UZ DIENSTHOOFD: OF NAAM VAKGROEPHOOFD: PROF. DR. PHILIP ROOSEN

7. PERIODE VAN HET SCRIPTIE Gedeelte (BEGIN- EN EINDDatum MAAND/JAAR)

OCTOBER 2016 – JUNI 2017

IK VERKLAR DE GEHELE VERANTWOORDelijkHEID VAN HET HIERBOVEN VERMLED PROJECT OP MIJ TE NEEMEN EN BEVESTIG DAT VOOR ZOVER DE HUIDIGE KENNIS HET TOELAAT, DE GEGEVEN INLICHTINGEN MET DE WERKELIJKHEID OVEREENSTEMMEN.

DE HOOFDONDERZOEKER

[Signature]

Datum: 30/10/2016

Naam: Ann Cools

Handtekening:

HET U.Z. DIENSTHOOFD OF DE VAKGROEPHOOFD (VOOR AKKOORD)

[Signature]

Datum: 26/11/2016

Naam: Philip Roosin

Handtekening:

VERZIE 19-09-2011
NAAM STUDENT

DATUM: 26/9/16
NAAM: Dimitri Audenaert
HANDETEKENING: [Signature]
DOCUMENT E (scripties – Z-lijn)

VERZOEK TOT ADVIES VAN HET ETHISCH COMITE BETREFFENDE EEN prospectief observationeel ONDERZOEKSPROJECT OP GEZONDHEIDSGEVEGENS VOOR HET maken van scripties en Z-lijn als deel van een reeds goedgekeurd academisch onderzoek (enkel verzameling van patiëntengegevens, vragenlijsten en interviews)

Dit document moet maar 1x ingediend worden indien de scriptie of Z-lijn kadert in een eerder goedgekeurde academische studie van de promotor (staatd. UZ Gent of U Gent).

De studenten moeten eerst contact opnemen met Prof.dr. R. Rubens voor verdere inlichtingen robert.rubens@UGent.be.

Wanneer de scriptie of Z-lijn niet verbonden is aan een globaal academisch onderzoek, maar enkel opgezet is voor de scriptiestudent, dan moet de indiening gebeuren via de standaardprocedure (document D)

1. TITEL VAN HET ONDERZOEK:

ONDERZOEK NAAR HET OPSTELLEN VAN EEN NORMATIEVE DATABASE VOOR FUNCTIONELE SCHOUDERTESTEN BIJ BOVENHANDSE SPORTERS

2. PROJECTNUMMER (EC), NAAM AANVRAGER VAN HET REEDS INGEDIENDE AKADEMISCH ONDERZOEK + DATUM GOEDKEURING:
   • PROJECTNUMMER: 2016/0963
   • NAAM ONDERZOEKER: ANN COOLS
   • DATUM GOEDKEURING: 13/9/2016

3. ONDERZOEK IN FUNCTIE VAN:
   □ BACHELOR SCRIPTIE
     • NAAM STUDENT(E(N):
     • OPLEIDING:
     • NAAM HOGESCHOOL:
     • E-MAIL STUDENT:
     • TEL. STUDENT:
   ✗ MASTERScriptIES of Z-LIJN
     • NAAM STUDENT(E(N): JEROEN BAELE
     • OPLEIDING: MASTER IN REVALIDATIEWETENSCHAPPEN EN KINESITHERAPIE
     • NAAM FACULTEIT: GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN
     • E-MAIL STUDENT: JETBAELE.BAELE@UGENT.BE
     • TEL. STUDENT: 0486428588

VERZIE 19-09-2011
4. SOORT ONDERZOEK

- VERZAMELEN VAN PATIËNTENGEGEVEN, DIE KLINISCH STANDAARD GEGEVEN ZIJN (GEEN ENKEL AANVULLENDE ONDERZOEK, BLOED- OF ANDERE STAALAFNAMEN)

- VRAGENLIJSTEN

- INTERVIEW

5. TAAK VAN DE STUDENT BIJ DICHT ONDERZOEK:

BEGELEIDEN VAN DE TESTMOMENTEN, VERZAMELEN VAN PATIËNTENGEGEVEN EN AFNEMEN VAN VRAGENLIJSTEN

6. GEGEVENS VAN DE PROMOTOR + AFFILIAATIE:

- NAAM: PROF. DR. ANN COOLS
- FUNCTIE: ZAP
- UZ DIENST:
  OF FACULTEIT/VAKGROEP: GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN, REVALUATIEWETENSCHAPPEN EN KINESITHERAPIE
  TELEFOONNUMMER: +329 332 26 33
  FAX: +329 332 38 11
  E-MAIL: ANN.COOLS@UGENT.BE
- NAAM UZ DIENSTHOOFD:
  OF NAAM VAKGROEPVOORZITTER: PROF. DR. PHILIP ROOSEN

7. PERIODE VAN HET SCRIPTIE GEDURELTE (BEGIN- EN EINDDATUM MAAND/JAAR)

OKTOBER 2016 – JUNI 2017

IK VERKLAR DE GEHELE VERANTWOORDelijkHEID VAN HET HIERBOVEN VERMELD PROJECT OP MIJ TE NEMEN EN BEVESTIG DAT VOOR ZOVER DE HUIDIGE KENNIS HET TOELAAT, DE GEGEVEN INLICHTINGEN MET DE WERKELIJKHEID OVEREENSTEMMEN.

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<tr>
<th>De Hoofdonderzoeker</th>
<th>Het U.Z. Diensthoofd of de Vakgroepvoorzitter (voor akkoord)</th>
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<td>DATUM:</td>
<td>DATUM:</td>
</tr>
<tr>
<td>NAAM: ANN COOLS</td>
<td>NAAM: PHILIP ROOSEN</td>
</tr>
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<td>HANDTEKENING:</td>
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VERSIE 19-09-2011
NAAM STUDENT

DATUM: 26-01-11

NAAM: JEROEN BAELE

HANDTEKENING: Baele

VERSIE 19-09-2011
DOCUMENT E (scripties – Z-lijn)

VERZOEK TOT ADVIES VAN HET ETHISCH COMITE BETREFFENDE EEN prospectief observationeel ONDERZOEKSPROJECT OP GEZONDHEIDSGEGEVEN VOOR HET maken van scripties en Z-lijn als deel van een reeds goedgekeurd academisch onderzoek
(enkel verzameling van patientengegevens, vragenlijsten en interviews)

Dit document moet maar 1x ingediend worden indien de scriptie of Z-lijn kadert in een eerder goedgekeurde academische studie van de promotor (staff UZ Gent of U Gent).

De studenten moeten eerst contact opnemen met Prof.dr. R. Rubens voor verdere inlichtingen robert.rubens@UGent.be.

Wanneer de scriptie of Z-lijn niet verbonden is aan een globaal academisch onderzoek, maar enkel opgezet is voor de scriptiestudent, dan moet de indiening gebeuren via de standaardprocedure (document D).

1. TITEL VAN HET ONDERZOEK:

ONDERZOEK NAAR HET OPSTELLEN VAN EEN NORMATIEVE DATABASE VOOR FUNCTIONELE SCHOUDERTESTEN BIJ BOVENHANDSE SPORTERS

2. PROJECTNUMMER (EC), NAAM AANVRAGER VAN HET REEDS INGEDIENDE AKADEMISCH ONDERZOEK + DATUM GOEDKEURING:

- PROJECTNUMMER: 2016/0063
- NAAM ONDERZOEKER: ANN COOLS
- DATUM GOEDKEURING: 13/9/2016

3. ONDERZOEK IN FUNCTIE VAN:

- BACHELOR SCRIPTIE
  - NAAM STUDENT(EN):
  - OPLEIDING:
  - NAAM HOGESCHOOL:
  - EMAIL STUDENT:
  - TEL. STUDENT:

- MASTERSCRIPTIES OF Z-LIJN
  - NAAM STUDENT(EN): JOREN CHRISTIAENS
  - OPLEIDING: MASTER IN REVALIDATIEWETENSCHAPPEN EN KINESTHERAPIE
  - NAAM FACULTET: GENEESKUNDE
  - EMAIL STUDENT: JOREN.CHRISTIAENS@UGENT.BE
  - TEL. STUDENT: 0478/149/473

VERZOEK 19-09-2011 1
4. SOORT ONDERZOEK

**VERZAMELEN VAN PATIËNTEGEREVEN**
- KLINISCH STANDAARD GEGEVEN ZIJN
  (=GEEN ENKEL AANVULLEND ONDERZOEK, BLOED- OF ANDERE STAALAFNAME)

**VRAGENLIJSTEN**
**INTERVIEW**

5. **TAAK VAN DE STUDENT BIJ DIJ ONDERZOEK:**

Begeleiden van de testmomenten, verzamelen van patiëntengegevens en aanvullende vragenlijsten

6. **GEGEVENS VAN DE PROMOTOR ± AFFILIAATIE:**

- **NAAM:** PROF. DR. ANN COOLS
- **FUNCTIE:** ZAP
- **UZ DIENST:**
  - FACULTEIT/VAKGROEP: GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN, REVALIDATIEWETENSCHAPPEN EN KINESITHERAPIE
- **TELEFOONNUMMER:** +329 332 26 33
- **FAX:** +329 332 38 11
- **E-MAIL:** ANN.COOLS@UGENT.BE
- **NAAM UZ DIENSTHOOFD:**
  - OF NAAM VAKGROEPVOORZITTER: PROF. DR. PHILIP ROOGEN

7. **PERIODE VAN HET SCRIPTIE GEDUREELTE (BEGIN- EN EINDDATUM MAAND/JAAR):**

**OCTOBER 2016 – JUNI 2017**

IK VERKLAR DE GEHELE VERANTWOORDELIJKHEID VAN HET HIERBOVEN VERMELD PROJECT OP MIJ TE NEMEN EN BEVESTIG DAT VOOR ZOVER DE HUIDIGE KENNIS HET TOELOAT, DE GEGEVEN INLICHTINGEN MET DE WERKELIJKHEID OVEREENSTEMMEN.

**DE HOOFDONDERZOEKER**

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<td>ANN COOLS</td>
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<tr>
<td>HANDTEKENING:</td>
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**HET UZ DIENSTHOOFD OF DE VAKGROEPVOORZITTER (VOOR AANKOORD)***

<table>
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<td>PHILIP ROOGEN</td>
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<td>/</td>
</tr>
</tbody>
</table>
NAAM STUDENT

DATUM: 2016
NAAM: JOREN CHRISTIAENS
HANDTEKENING

VERSIE 19-09-2011
Signed document of laboratory agreements
Signed document of laboratory confidentiality

VERTROUWELIJKHEID & OVERDRACHT VAN RECHT
EENZIJIGE VERKLARING

NDA-EV

Deze Verklaring wordt afgelegd ten aanzien van
Universiteit Gent, openbare instelling met rechtspersoonlijkheid, waarvan de bestuurszetel
gevestigd is te 9000 Gent, Sint-Pietersnieuwstraat 25, gekend onder ondernemingsnummer
0248.015.142 en vertegenwoordigd door prof. dr. Anne De Paepe, handelend in haar hoedanigheid
van Rector (hierna kortweg aangeduid als "UGent")

Door:

AUDENAERT DIMITRI

Student, ingeschreven aan UGent in de richting: REVAKI

Project: OPSTELLEN VAN EEN NORMATIEVE DATABASE VOOR
FUNCTIONELE SCHOUVERTESTEN BIJ BOVENHANDSE
SPORTERS

In het kader van zijn/haar opleiding aan UGent, zal ondergetekende kennis krijgen van bepaalde
vertrouwelijke informatie toebehorend aan UGent of door derden toevertrouwd aan UGent.

Ondergetekende verbindt er zich toe om de aan hem/haar in het kader van het Project ter
beschikking gestelde informatie op geen enkele manier publiek bekend te maken zonder
voorafgaande uitdrukkelijke schriftelijke toelating van UGent. Deze verbindtens geldt voor een duur
van tien jaar te rekenen vanaf de datum van deze Eenzijdige Verklaring.

Ondergetekende draagt eveneens al zijn/haar rechten op onderzoeksresultaten behaald in het kader
van het Project over aan UGent.

Deze Eenzijdige Verklaring vervangt alle schriftelijke en mondelinge overeenkomsten die de partijen
eerder zijn aangegaan met betrekking tot haar voorwerp en omvat de enige en volledige
overeenkomst ter zake tussen de partijen.

Aldus verklaart en tekent voor akkoord:

<table>
<thead>
<tr>
<th>Naam</th>
<th>AUDENAERT DIMITRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handtekening</td>
<td>Voorafgegaan door handgeschreven vermelding &quot;gelezen en goedgelezen&quot;</td>
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<tr>
<td>Datum:</td>
<td>28/04/2016</td>
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UGENT Onderzoeksvereenkomsten [ev - 2014] VERTROUWELIJK

PAGINA 1 VAN 1
VERTRouWELIJKHEID & OVERDRACht VAN RECHt
EENZIJDige VERKLARING

NDA-EV

Deze Verklaring wordt afgelegd ten aanzien van

Universiteit Gent, openbare instelling met rechtspersoonlijkheid, waarvan de bestuurszetel gevestigd is te 9000 Gent, Sint-Pietersnieuwstraat 25, gekend onder ondernemingsnummer 0248.015.142 en vertegenwoordigd door prof. dr. Anne De Paepe, handelend in haar hoedanigheid van Rector (hierna kortweg aangeduid als "UGent")

Door:

BAELE JEROEN

Student, ingeschreven aan UGent in de richting: REVAKI

Project: OPSTELLEN VAN EEN NORMATIEVE DATABASE VOOR FUNCTIONELE SCHOUWRETESTEN BIJ BOVENKANDE SPORTERS

In het kader van zijn/haar opleiding aan UGent, zal ondergetekende kennis krijgen van bepaalde vertrouwelijke informatie toebehorend aan UGent of door derden toevertrouwd aan UGent.

Ondergetekende verbindt er zich toe om de aan hem/haar in het kader van het Project ter beschikking gestelde informatie op geen enkele manier publiek bekend te maken zonder voorafgaande uitdrukkelijke schriftelijke toelating van UGent. Deze verbintenis geldt voor een duur van tien jaar te rekenen vanaf de datum van deze Eenzijdige Verklaring.

Ondergetekende draagt eveneens al zijn/haar rechten op onderzoeksresultaten behaald in het kader van het Project over aan UGent.

Deze Eenzijdige Verklaring vervangt alle schriftelijke en mondelinge overeenkomsten die de partijen eerder zijn aangegaan met betrekking tot haar voorwerp en omvat de enige en volledige overeenkomst ter zake tussen de partijen.

Aldus verklaart en tekent voor akkoord:

<table>
<thead>
<tr>
<th>Naam</th>
<th>BAELE JEROEN</th>
</tr>
</thead>
<tbody>
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<td>Handtekening</td>
<td>&quot;gelezen en goedgekend&quot;</td>
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<td>Datum</td>
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UGent ONDERZOEKSOVEREENKOMSTEN (ev. - 2014)  VERTRouWELIJK  PAGINA 3 VAN 1
VERTRouWELIJKHEd E& OvErDrACHT VAn R Ecch
EEnZIJDIGE VeRKLARING

NDA-EV

Deze Verklaring wordt afgelegd ten aanzien van
Universiteit Gent, openbare instelling met rechtspersoonlijkheid, waarvan de bestuurszetel
gevestigd is te 9000 Gent, Sint-Pietersnieuwstraat 25, gekend onder ondernemingsnummer
0248.015.142 en vertegenwoordigd door prof. dr. Anne De Paepe, handelend in haar hoedanigheid
van Rector (hierna kortweg aangeduid als "UGent")

Door:

CHRISTIAENS JOREN

Student, ingeschreven aan UGent in de richting: REVAKI

Project: OPSTELLEN VAN EEN NARRATIEVE DATABASE VOOR FUNCTIONELE SCHOUDBESTANDS
BIJ ONGEHINDERDE SWEEKERS

In het kader van zijn/haar opleiding aan UGent, zal ondergetekende kennis krijgen van bepaalde
vertrouwelijke informatie toebehorend aan UGent of door derden toevertrouwde aan UGent.
Ondergetekende verbindt er zich toe om de aan hem/haar in het kader van het Project ter
beschikking gestelde informatie op geen enkele manier publiek bekend te maken zonder
voorafgaande uitdrukkelijke schriftelijke toelating van UGent. Deze verbintenis geldt voor een duur
van tien jaar te rekenen vanaf de datum van deze Eenzijdige Verklaring.
Ondergetekende draagt eveneens al zijn/haar rechten op onderzoeksresultaten behaald in het kader
van het Project over aan UGent.
Deze Eenzijdige Verklaring vervangt alle schriftelijke en mondelinge overeenkomsten die de partijen
eerdere zijn aangegaan met betrekking tot haar voorwerp en omvat de enige en volledige
overeenkomst ter zake tussen de partijen.

Aldus verklaart en tekent voor akkoord:

<table>
<thead>
<tr>
<th>Naam</th>
<th>CHRISTIAENS JOREN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handtekening</td>
<td>Voorafgegaan door handgeschreven vermelding &quot;gelezen en goedgekeurd&quot;</td>
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<td></td>
<td>Gelezen en goedgekeurd</td>
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Datum: 28/04/2016
## Table X. Correlation Coefficients, Coefficient of Determination and Difference (P Values) between the functional tests

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>r</th>
<th>R²</th>
<th>P Value</th>
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<td>HHD ER ND</td>
<td>YBT-UQ COMP ND</td>
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<td>YBT-UQ COMP D</td>
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<tr>
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<tr>
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<td>0.043</td>
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<tr>
<td>HHD IR ND</td>
<td>YBT-UQ IL D</td>
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<td>HHD ER ND</td>
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<tr>
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<td>YBT-LQ COMP D</td>
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<td>0.093</td>
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<td>0.054</td>
<td>0.017</td>
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</table>

COMP normalized composite scores, ND non-dominant side, D dominant side, MED medial, IL inferolateral, PM posteromedial, PL posterolateral, IR internal rotation, ER external rotation, r correlation, R² Coefficient of Determination