An Upper Body Musculoskeletal Assessment Instrument for Patients with Work-related Musculoskeletal Disorders:

A Pilot Study

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ABSTRACT: *Objectives:* To examine the reliability and validity of a new outcome measure, the Upper Body Musculoskeletal Assessment (UBMA). *Design:* Twenty subjects physician-diagnosed as having work-related musculoskeletal disorders (WRMD) and ten healthy subjects were assessed using the UBMA on three separate occasions. All subjects with WRMD attributed their injury to equipment use on their job. *Results:* The WRMD group had significantly higher UBMA scores on the side of equipment use than on the other side ($p < 0.01$), whereas the healthy group had similar scores on both sides ($p > 0.05$). UBMA scores for the WRMD group were significantly greater on both sides of the body than scores for the healthy group ($p < 0.01$). Only one test occasion was required to produce excellent reliability coefficients (ICCs > 0.88). Although group reliability was excellent, changes of 24% for patients with WRMD and 44% for healthy subjects would be required for confidence that UBMA scores for individual patients on the side of equipment use had changed from baseline. *Conclusions:* Although testing on one occasion produced reliable UBMA scores, healthy subjects could be distinguished from patients with WRMD, and the side of equipment use could be distinguished from the other side in patients with WRMD, prediction of individual UBMA scores was poor. In its present form, the UBMA is useful for making decisions about groups but not about individual patients. Modifications of the current UBMA are required to reduce measurement error.

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A dramatic increase in the number of musculoskeletal disorders attributed to work-related causes has been associated with the increasing performance of repetitive tasks.[1,2] The clinical presentations of these disorders have variously been called repetitive strain injuries, overuse syndrome, cumulative trauma disorders, and, more recently, work-related musculoskeletal disorders (WRMDs).[1–3] Workplace stressors such as repetitions, forceful motions using one or both sides of the body, mechanical stresses, static or awkward postures, local vibration, and cold temperatures[2–4] are thought to produce a variety of musculoskeletal disorders of the upper extremity. Manifestations of these disorders can often be detected on physical examination as tendinitis,[5,6] tenosynovitis, bursitis, epicondylitis,[6] carpal tunnel syn-

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drome, Guyton tunnel syndrome, cubital tunnel syndrome,[2,3,7,8] tender points,[8,9] and myalgia.[10] To what extent these affect WRMDs is unclear and cannot be readily assessed until a means to quantify WRMD is developed.

Because WRMDs are multi-factorial in presentation, tests that use only one or a few items are unlikely to be definitive in diagnosing WRMD. For assessment of WRMD, Andersson et al.[2] suggested the inclusion of nerve integrity tests, including the Phalen, Tinel, and Finkelstein tests, to assess first dorsal compartment inflammation, and the Adson test to assess thoracic outlet syndrome. They also suggested that pain on resisted movement, when enough resistance is used to maintain an isometric contraction, as well as limitations in range of motion and the presence of tenderness points should be included in the assessment.

Our goal in developing the upper body musculoskeletal assessment (UBMA) was to produce a single outcome measure that quantified WRMD and could be useful in clinical diagnosis and evaluation of progress. The UBMA includes neurologic, musculoskeletal, and vascular elements as well as grip and pinch strength (using Jamar and pinch dynamometers). It also includes pinprick sensation of the digits,[11] tender points of the shoulder complex,[12] pain reported during resisted contractions, passive range of motion for all upper extremity joints, and the subjective reporting of duration, frequency, and intensity of pain and discomfort[13] for all upper extremity limb segments. The UBMA takes a regional (i.e., of the body) approach to diagnosis and quantification using clinically common tests. The UBMA differs from the DASH (Disabilities of the Arm, Shoulder and Hand) questionnaire[14] by being oriented toward perceived pain and discomfort, not disability.

The purpose of the present study was to determine the test–retest reliability of the UBMA and to determine whether this test could distinguish between subjects with and without WRMD and between the involved and uninvolved (or less involved) arms of those with WRMD.

METHODS

Subjects

Twenty subjects who had been diagnosed by one of two physicians as having WRMD and ten healthy subjects who reported no work-related musculoskeletal discomfort gave informed consent to testing (see Table 1 for subject demographics) on three occasions. Each test required 20 to 30 minutes, and all tests for any one subject were completed in the laboratory or at the subject's home, at the discretion of the subject. The three tests were competed one-to-two days apart and within one week. Both the right and the left upper extremities were tested on each occasion, in random order. Parts of the UBMA itself were also conducted in random order to reduce the likelihood of the subjects' remembering their performance or previous response on a particular item. The subjects with WRMD had engaged in repetitive work that included clerical, office, and secretarial occupations and industrial and manual labor occupations.

Testers

Two clinicians, a physical therapist, and an occupational therapist assessed all subjects in a standardized manner using the UBMA. Both clinicians had used similar assessments during their clinical practice for at least four years and had independently tested at least three subjects using the UBMA prior to the present study. The two testers were considered to be equally proficient. Matching of tester to subject was based on tester availability. Between-tester reliability was not examined in this study.

Assessment

The maximum possible score on the UBMA was 152 for each side, calculated from 51 items for each side of the body, with higher scores indicating greater involvement (Appendix 1). The items tested and the scoring system were developed by the research team on the basis of their personal clinical experience.

All testing was completed with the client sitting in a minimally padded chair. The active-resisted condition consisted of movements to mid-range, resisted by the tester against the client's maximum contraction, and scored on a 0 to 4 scale (12 items; maximum section score 48). Passive range of motion was measured in degrees using a standard goniometer and then converted to a score of 0 to 3 (8 items; maximum section score 14). Pressure points of the upper extremity were assessed using moderate finger pressure applied by the tester and scored 0 to 2 (9 items; maximum section score 18). Similarly, neurologic signs were assessed on a 0 to 2 scale (4 items; maximum section score 8). Grip and pinch strength were measured in Newton force using a goniometer and were scored relative to normal values[15] on a scale of 0 to 2 (2 items; maximum section score 4). Sensation was measured for each finger using a pin, and scored on a scale of 0 to 2 (5 items; maximum section score 10). Forearm swelling was assessed subjectively, by the tester applying finger pressure to the area and observing indentations, and scored 0 to 1 (2 items; maximum section score 2). Pain and discomfort of the shoulder, elbow, and wrist were self-reported by the subject and scored 0 to 7 for duration, 0 to 5 for frequency, and 0 to 4 for intensity (9 items; maximum section score 48).

Data Analyses

A UBMA score was generated for each side of the body, as defined on the basis of usage of the upper extremity—that is, the arm or side with which the subject predominantly used equipment (the side of equipment use) and the other arm or side. A three-way analysis of variance (ANOVA) test (two groups × two sides × three test occasions) was used to compare UBMA scores. Following a significant F ratio, a Newman-Keuls test was used to compare pairs of means.[16]

Test–retest reliability of UBMA scores was determined for the upper extremity on the side of equipment use and on the other side, using intraclass correlation coefficients (ICCs)[17]—specifically, $ICC_{2,1}$ (the reliability of any one occasion) and $ICC_{2,3}$ (the reliability of the mean of three occasions). The ICCs were interpreted as follows: poor, 0.00 to 0.40; good, 0.40 to 0.74; excellent, greater than or equal to 0.75.[18] The standard error of measurement (SEM) and 95% confidence intervals (95% CIs) were calculated to quantify variation in units of UBMA scores.[19]

RESULTS

At the time of testing, the 20 subjects in the WRMD group represented a variety of employment backgrounds and included manual laborers, industrial workers, clerical personnel, and a student (Table 1), among others. All WRMD subjects attributed their injury to their job. Prior to the present study, 11 subjects were employed in industrial or manual labor occupations. At the time of testing, six of these subjects remained in industrial or manual labor occupations, four were unemployed, and one had changed to a clerical occupation. Of the nine subjects who were employed in clerical occupations prior to injury, only two had changed occupations—one became unemployed and one became a student. Overall, seven subjects (35% of the WRMD group) had changed occupational status as a result of their injury.

TABLE 1. **Subject Demographics**

Group	*Age (years)†*	*No. Female/ Male*	*Side of Use*	*Employment*
WRMD ($n=20$)	43 ± 8	18/2	15R/5L	8 clerical, office, or secretarial 6 industrial or manual labor 1 student 5 unemployed
Healthy ($n=10$)	40 ± 7	8/2	9R/1L	4 university faculty 3 university students 1 clinician 2 office staff

NOTES: WRMD indicates work-related musculoskeletal disorder; Side of Use, the arm or side with which the patient used equipment predominantly.
* Employment category at time of testing.
† Mean ± SD.

TABLE 2. **Mean ± SD UBMA Scores**

Occasion	*WRMD Group (n=20)*		*Healthy Group (n=10)*	
	Side of Use	*Other Side*	*Side of Use*	*Other Side*
One	50 ± 18	31 ± 22	9 ± 8	8 ± 9
Two	50 ± 18	32 ± 24	9 ± 8	7 ± 10
Three	50 ± 23	31 ± 27	7 ± 9	6 ± 8
MEAN	50 ± 19	31 ± 24	8 ± 8	7 ± 9

Notes: Scores are expressed as mean ± SD. Maximum score is 152. WRMD indicates work-related musculoskeletal disorder. Side of Use indicates the arm or side with which the subject predominantly used equipment.

The average time since diagnosis for the WRMD subjects was one year. All subjects in the healthy group were employed or attending university. None of the healthy subjects were employed in manual labor or industrial occupations, and all used computers and video display terminals in their work.

Tester A, with a physical therapy background, assessed ten WRMD subjects and all ten healthy subjects. Tester B, with an occupational therapy background, assessed ten WRMD subjects and no healthy subjects.

Fifteen of the WRMD subjects used equipment primarily with their right hand, while nine of the healthy subjects did so (see Table 1). All subjects used the equipment primarily with their dominant side. Of the 12 subjects in the WRMD group who were affected unilaterally, all used equipment with their more affected side. Although three of the healthy subjects reported some symptoms of pain and discomfort at the time of testing, they did not consider it severe enough to consult a physician.

On the ANOVA, the main effects for group and side and the group × side interaction were significant ($p<0.05$). Subsequent post-hoc analysis of the interaction indicated that the UBMA scores for the WRMD group were significantly greater than those for the healthy group, and the UBMA score for the WRMD group was significantly greater on the side of equipment use than on the other side ($p<0.01$), while no difference was observed between the sides for the healthy group ($p>0.05$) (Table 2 and Figure 1). On the main effects, scores for the WRMD group were significantly greater than those for the healthy group, and scores on the side of equipment use were significantly greater than those on the other side ($p<0.01$). No occasion-related effects were observed on the ANOVA ($p>0.05$).

Reliability coefficients for any one occasion were excellent (ICCs, 0.88 to 0.94) (Table 3). Although ICCs

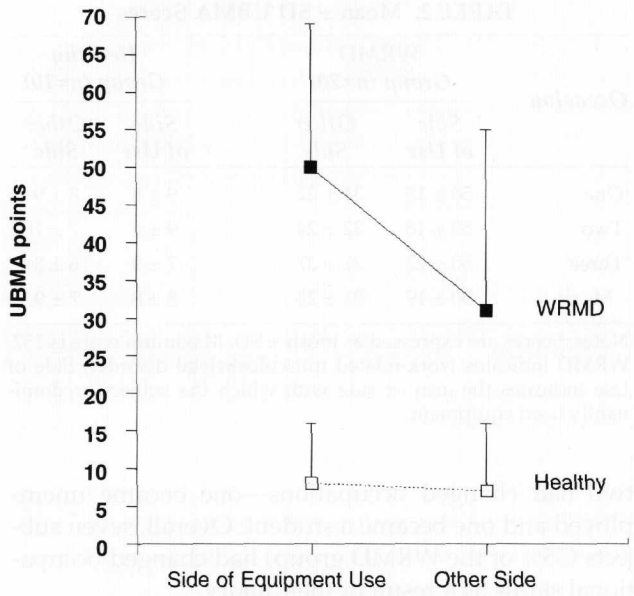

FIGURE 1. Scores for the Upper Body Musculoskeletal Assessment for the group of patients with work-related musculoskeletal disorders (WRMD; n = 20) and for the healthy group (n = 10), on the side of equipment use and on the other side. Vertical lines represent standard deviations.

were improved by averaging scores over three test occasions, these were not appreciably improved (ICCs, 0.92 to 0.96). The ICCs for the WRMD and healthy groups and for the sides were similar. However, SEMs and 95% CIs were smaller for the healthy group.

DISCUSSION

No significant differences were observed between the scores for either side on the three occasions, and excellent ICCs were observed when testing on only one occasion, for both WRMD and healthy groups. Because ICCs for one occasion were already high, additional testing did not appreciably increase these reliability coefficients (Table 3). In practical terms, testing on additional occasions produced a diminishing benefit and conducting additional tests in an effort to maximize test–retest reliability may not be cost-effective.

Although these results suggest that the UBMA can produce reliable scores for both the WRMD and healthy groups, the predictive utility of the UBMA for individual patients is less clear. In practice, a patient with an observed UBMA score of 50 for the side of equipment use (maximum score 152), determined from only one test occasion, could have a true score between 38 and 62 points (95% CI ± 12). For confidence that a true change in score occurred from the baseline score of 50, the new score would have to be less than 38 or greater than 62—about 24% change from baseline. Similarly, the true score for a healthy person with a baseline UBMA score of 9 could lie between 5 and 13 (95% CI ±4), requiring a change of about 44% from baseline for confidence that any new score was unlikely to be attributed to measurement error. As a result, measurement error makes questionable the precision of determining an individual score and evaluating patient progress; relatively large changes in a subsequent UBMA score would be required for confidence that the new score was unlikely to be attributable to normal variation with testing.

Differences Between Groups and Sides

Twelve of the WRMD subjects had bilateral involvement, although they were able to identify one side as being clearly more affected. The other eight WRMD subjects reported some bilateral involvement, but not to the extent that their physician had diagnosed them as having WRMD bilaterally. The UBMA differentiated between the WRMD and healthy groups and between the side of equipment use and the other side. These findings do convey some validity to the UBMA as an outcome measure that can discriminate between groups and sides. However, the subjects examined in this study were from two highly divergent groups—the mean score for the WRMD group was about five times that of the healthy group on the side of equipment use. Whether the UBMA can differentiate between two less distinct groups or conditions requires further study.

The finding of higher WRMD scores for the upper extremity on the side of equipment use is in agreement with findings reported by Kucera and Robins.[20] They found that dominance of hand use was a significant risk factor on the development of WRMD. In the present study, the side of equipment use was consistently the side most affected. Despite tending to use equipment (e.g., a computer mouse) primarily with one upper extremity, the healthy group demonstrat-

TABLE 3. **Intraclass Correlation Coefficients (ICCs), Standard Errors of Measurement (SEMs), and 95% Confidence Intervals (95% CIs)**

Reliability	*WRMD Group (n = 20)*		*Healthy Group (n = 10)*	
	Side of Use	*Other Side*	*Side of Use*	*Other Side*
Of any one occasion:				
ICC	0.88	0.94	0.94	0.89
SEM	6	5	2	2.5
95% CI	12	10	4	5
Of the mean of three occasions:				
ICC	0.92	0.96	0.96	0.93
SEM	5	5	2	3
95% CI	10	10	4	6

NOTES: WRMD indicates work-related musculoskeletal disorder. Side of Use indicates the arm or side with which the subject predominantly used equipment.

ed much lower scores on the UBMA and no difference between sides.

Post-hoc comparison of the two testers on the WRMD scores indicated no tester effect ($p>0.05$); each tester had assessed ten WRMD subjects (ANOVA—two testers × two sides × three occasions[16]) Post-hoc comparison of scores for subjects tested in the laboratory and scores for those tested at home was not feasible, because only two of the WRMD subjects were tested in the laboratory, whereas 18 were tested at home. Although all the healthy subjects were tested in the laboratory, we do not think that the UBMA healthy subject differential was attributable to the test environment, since the mean score for the WRMD subjects was about five times that of the healthy subjects.

The UBMA reported here reflects a general approach to quantifying WRMD by assessing several aspects of the condition rather than one or a few specific aspects. The present items were selected and weighted by a team that included a physician, occupational and physical therapists, and kinesiologists, and were based on their clinical experience with WRMD patients and on the available literature.

The present study offers one means of quantifying WRMD. Given the finding that the present UBMA did not provide a high degree of prediction for individual subjects, modifications of the UBMA—adding or deleting items, re-weighting the scoring system, or a combination of these—need to be explored with the intent of decreasing measurement error.

CONCLUSIONS

The UBMA produced scores with excellent test–retest reliability when used on only one test occasion, and differentiated between the WRMD and the healthy group as well as between the side of equipment use and the other side. However, prediction of individual performance was limited, allowing for changes of 24% from baseline for WRMD subjects and 44% from baseline for healthy subjects before a true change in UBMA score could be detected on the side of equipment use. The UBMA as reported here presents one means of combining and weighting test items to produce a global score to describe WRMD. Modifications of the present UBMA, with the goal of decreasing measurement error, are required if it is to be used to help in diagnosis or in the making of decisions about the progress of individual patients with WRMD.

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The appendix appears on the next page

Appendix

UPPER BODY MUSCULOSKELETAL ASSESSMENT (UBMA)

Instructions:

1. Client is seated.
2. Both sides are assessed, the least painful side (if there is one) first.

   Separate scores are calculated for the right and left sides.
3. Do active movements first; then passive.
4. During active movements, apply resistance at the mid-range (for only a few seconds)

Give adequate explanation and practice, then one test repetition.

1. Pain on Active Resisted Contractions

Using manual resistance provided by the tester, score the pain experienced during active contractions as follows:

0 = no pain,
1 = mild pain
2 = moderate pain
3 = severe pain, and
4 = worst pain ever experienced

Neck lateral flexion ___	Neck rotation ___
Shoulder abduction ___	Shoulder extension ___
Shoulder flexion ___	
Shoulder internal rotation ___	Shoulder external rotation ___
Elbow flexion ___	
Wrist extension ___	Wrist flexion ___
Back lateral flexion ___	Back lateral rotation ___

2. Passive Range of Motion

Shoulder abduction—With elbow extended, arm is lifted out to the side as far as it will go. Goniometer axis is placed at shoulder joint from the back; the movement begins with the arm parallel to the side. Score as follows: <90°, score 3; 91°–120°, score 2; 121°–160°, score 1; and >160°, score 0.

Shoulder extension—With elbow flexed at 90°, arm is lifted backwards as far as it will go. Goniometer axis is placed at shoulder joint from the side; movement is measured beginning with the arm parallel to the side. Score as follows: <40°, score 1; >40°, score 0.

Shoulder flexion—With elbow extended, arm is lifted forward as far as it will go. Goniometer axis is placed at shoulder joint from the side; movement is measured beginning with the arm parallel to the side. Score as follows: 0°–90°, score 3; 91°–120°, score 2; 121°–160°, score 1; >160°, score 0.

Shoulder internal rotation—With elbow flexed at 90°, shoulder abducted to 90°, and forearm and hand pointing forward, shoulder is rotated forward as far as it will go so that the forearm and hand move downward while the elbow and shoulder is maintained at 90° of flexion and abduction respectively. Goniometer axis is placed at elbow distal to the joint angle; movement is measured beginning with the forearm parallel to the floor. Score as follows: <70°, score 1; >70°, score 0.

Shoulder external rotation—With elbow flexed at 90°, shoulder abducted to 90°, and forearm and hand pointing backward, shoulder is rotated forward as far as it will go so that the forearm and hand move upward while the elbow and shoulder are maintained at 90° of flexion and abduction respectively. Goniometer axis is placed at elbow distal to the joint angle; movement is measured beginning with the forearm parallel to the floor. Score as follows: <70°, score 1; >70°, score 0.

Elbow flexion—With elbow fully extended and arm hanging by the side of the body, shoulder in neutral position, and forearm supinated, elbow is flexed upward as far as it will go so that the forearm comes into contact with the biceps muscle. Goniometer axis is placed over the lateral epicondyle of the humerus; movement is measured beginning with the fingertips pointing to the floor. Score as follows: <150°, score 1; >150°, score 0.

Wrist extension—With fingers relaxed and hand resting on its ulnar side, the wrist is extended. Goniometer axis is placed at wrist beginning with the hand parallel to the forearm. Score as follows: 0°–30°, score 2; 31-50°, score 1; >50°, score 0.

Wrist flexion—With fingers relaxed and hand resting on its ulnar side, the wrist is flexed. Goniometer axis is placed at wrist beginning with the hand parallel to the forearm. Score as follows: 0°–30°, score 2; 31°–50°, score 1; >50°, score 0.

3. Pressure Points

With the client sitting passively, apply moderate finger pressure at the following sites. Score 2 for the presence of tenderness at each site, and 0 for no tenderness.

Deltoid—pressure on insertion of middle deltoid

Infrascapular—pressure on midpoint between spine and axilla

Trapezius—pressure on superior medial angle of the scapula

Lateral epicondyle—pressure on the lateral surface of the elbow (easily found when flexed)

Medial epicondyle—pressure on the medial surface of the elbow (easily found when flexed)

Forearms, dorsal—pressure on dorsal surface of forearm at muscle mass

Forearms, volar—pressure on volar surface of forearm at muscle mass

Wrist, dorsal—pressure on dorsal surface of wrist

Wrist, volar—pressure on volar surface of wrist

4. Neurologic Tests and Signs

Score 2 for each positive sign—the presence of tingling or pain in the fingers within 20 sec—and 0 for each negative sign.

Finkelstein test—The client makes a fist with the thumb inside the fingers; the examiner stabilizes the forearm and ulnarly

*This is the item sheet, not the scoring sheet.

deviates the wrist. A positive sign is pain over the abductor pollicis longus and extensor pollicis brevis tendons at the wrist and is indicative of a tenosynovitis in these two tendons. Because the test may cause discomfort in normal persons, the examiner should compare the pain caused on the affected side with sensation on the normal side.

Tinel test—Moderately tap on inside of wrist with hand relaxed.

Phalen test—Patient places dorsal surfaces of hands together with wrists maximally flexed.

Adson test—Shoulder is slightly extended and abducted with elbow extended, and head is turned to the opposite side. Technician monitors radial pulse.

5. Muscular Strength

Use a hand-grip dynamometer and a pinch dynamometer to collect measures, and then compare these measures to normative data provided by Trombly[15] to derive the score for the UBMA, as follows: <2 SD below normal, score 2; <1 SD below normal, score 1; >normal, score 0.

6. Finger Sensation

Test using pinprick on palmar surface of each fingertip. Score 2 for presence of decreased sensation of fingertip and 0 for normal sensation.

7. Forearm Swelling

Observe the dorsal surface of the hand and forearm. Compare hands, look for skin folds, apply pressure to area to observe any resulting indentations. Score 1 for presence of forearm swelling and 0 for no swelling.

8. Self-reported Discomfort

Questions 1 to 4 are used for information purposes, they are not scored.

1. Have you had symptoms of pain, aching, stiffness, burning, tingling, or numbness of any or all of the shoulder, elbow, hand, or wrist over the past six or more months?

   ___ Yes ___ No

2. Have you had any accident or trauma to the joint(s) that you identified above? If yes, please describe in detail.

3. When did your symptoms begin?

   _____

4. Have your symptoms occurred at, or immediately following, your present work at your job?

   ___ Yes ___ No

5. If symptoms have been identified in any joint area, as noted in the questions above, OR if any symptomatic area has arisen from the other tests previous to these questions, ask about the duration, frequency, and intensity of the problem over the last year, one joint at a time.

Duration:

How long does this shoulder (elbow or wrist) problem usually last?	Score
___ No shoulder (elbow or wrist) problem	0
___ Less than 1 hour	1
___ 1 hour to 1 day	2
___ More than 1 day to 1 week	3
___ More than 1 week to 2 weeks	4
___ More than 2 weeks to 4 weeks	5
___ More than 1 month to 3 months	6
___ More than 3 months	7

Frequency:

How often have you had this shoulder (elbow or wrist) problem in the past year?	Score
___ No shoulder (elbow or wrist) problem	0
___ Almost never (every six months)	1
___ Rarely (every 2-3 months)	2
___ Sometimes (once a month)	3
___ Frequently (once a week)	4
___ Almost always (daily)	5

Intensity:

On average, describe the intensity of the shoulder (elbow or wrist) problem.	Score
___ No shoulder (elbow or wrist) problem	0
___ Mild pain	1
___ Moderate pain	2
___ Severe pain	3
___ Worst pain ever in life	4

_____

Calculate UBMA scores for the right and left sides. Maximum score is 152 on each side.