ORIGINAL

The relationship between movement self-screening scores and pain intensity during daily training

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Abstract : Background : Various musculoskeletal screening and functional performance tests are used to evaluate physical condition. However, validated analysis tools that can identify gaps in pain knowledge during athletes' daily training are lacking. This study aimed to investigate the relationship between pain intensity in athletes during their daily training and the KOJI AWARENESS™ test in order to determine whether body dysfunction is related to pain among athletes. Methods : This cross-sectional study was conducted in a fitness center at the authors' affiliated institution. Thirty-five athletes (17 women and 18 men) aged 20-40 years were selected for study participation. KOJI AWARENESS™ self-evaluated test scores and pain intensity during daily training, as assessed on the numerical rating scale (NRS), were recorded. Results : The KOJI AWARENESS™ score showed a strong negative correlation with the NRS score for pain intensity during daily training ($r = -0.640$, $P < 0.001$). There was a significant negative correlation between KOJI AWARENESS™ and NRS scores, even when body mass index, sex, and age were entered as control variables. Conclusions : KOJI AWARENESS™ was highly accurate in detecting pain in athletes during their training. J. Med. Invest. 69 : 204-216, August, 2022

Keywords **:** *physical awareness, pain, sports training, sports and exercise science, physical activities*

INTRODUCTION

Pain is a common problem among elite athletes and is frequently associated with sports injuries, interfering with performance (1). Pain management should be based on the physiological, anatomical, and psychosocial influences on the individual's pain and is not equivalent to injury management, which focuses on musculoskeletal recovery and return to play (2).

In biomechanical studies, one joint mobility restriction might lead to excessive mobility at another joint, and postural control deficits might result in undesirable movement (3, 4). In 2011, Hodges claimed that undesirable movement involving joint mobility restrictions and postural control deficits lead to increased incidence of pain or injury (5). Identifying the gaps in knowledge regarding pain management for elite athletes will provide a speedy return to active sport and benefit performance (6). Various musculoskeletal screening and functional performance tests are conducted in the medical, healthcare, and sports settings to evaluate an individual's physical condition. However, validated analysis tools that can identify gaps in pain knowledge during athletes' daily training are lacking.

KOJI AWARENESS™ was developed as a self-check screening test that can be used without special equipment or evaluation by a trained expert. The test helps in understanding the daily condition of health-conscious people, including athletes and the elderly. KOJI AWARENESS™ consists of 11 individual components for the assessment of combinations of mobility, stability, and strength. Each component of KOJI AWARENESS™ is organized to reflect the corresponding body segments so that subjects can immediately recognize the dysfunctional body region by themselves.

This study compared the relationship between athletes' pain intensity on the numerical rating scale (NRS) during their daily training and the total points on the KOJI AWARENESS™ test in order to determine whether body dysfunction is related to pain among athletes. We hypothesized that the self-screened KOJI AWARENESS™ score is negatively related to pain in athletes.

MATERIALS AND METHODS

Subjects

The investigators recruited subjects from the client of the Sports Science Center at Tokyo Medical and Dental University. A total of 35 athletes (17 women and 18 men, aged 23.0 [5.0] years and body mass index 22.2 [5.2] kg/m^2) volunteered participated in this experiment. Subjects were included if they met the following inclusion criteria : (i) an athletic level, from regional collegiate level to being an Olympic medalist ; (ii) age between 20 and 40 years ; and (iii) ability to complete their daily training program without interference with severe injury for three months. Subjects were excluded if any of the following conditions were met : (i) severe psychiatric, neurological, or cardiovascular diseases ; (ii) orthopedic disorders ; (iii) pregnancy ; and (iv) acute infectious disease. Prior to screening, all subjects provided written informed consent for their participation in this study. The participants were instructed to stop when they felt pain during any part of the test. This study was conducted in accordance with the ethical principles embodied in the Declaration of

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Helsinki (52nd WMA General Assembly, Edinburgh, Scotland, October 2000) for medical research involving human subjects and was approved by the Research Ethics Committee of Tokyo Medical and Dental University (research protocol identification number : M2019-168).

Types of sport and demographic characteristics

The type of sport, including events and level of competition, was recorded on the day of testing. On the day of testing, age, sex, height, and weight were recorded. Body mass index (BMI) was calculated based on the height and weight of each subject.

Movement screening tests : KOJI AWARENESS™

Further details on KOJI AWARENESS™ are provided in Appendices 1 and 2. It comprises range-of-motion measurements (7-12) and muscle strength measurements (13-17). Athletes use a checklist to self-evaluate the function of each body part (18-21). There are 11 designated movements for self-evaluation, and each component has distinct scoring criteria, with a maximum total score of 50 points. Each component of the KOJI AWARENESS™ test is divided to reflect the corresponding body segments so that subjects can immediately locate the dysfunctional body region. The method for KOJI AWARENESS™ was explained to the participants until they understood it. Subsequently, they self-rated the motor function of each item according to the method presented in Appendices 1 and 2. For this test, up to three attempts were allowed, and the best score was retained. All exercises were photo-documented to ensure accurate scoring. The participants completed the assessment within an average of 20 min. To improve reproducibility, all subjects completed the KOJI AWARENESS™ test with guidance from the same athletic trainer (ATC), who was certified by the National Athletic Trainers' Association. Unilateral and asymmetrical tests were performed on both sides of the body. The intra- and inter-rater reliabilities of KOJI AWARENESS™ were 0.876 and 0.993, respectively, which confirms the high reproducibility of this study.

NRS

All 35 athletes completed the NRS questionnaires to assess pain intensity during their daily training within one week of the experience test. Athletes expressed the location of their pain and their pain intensity numerically from to 0-10 (no pain to worst pain). The points were added for the maximum NRS score. NRS assessment is a standardized method with high reproducibility and validity (22).

Statistical analysis

The normality of distribution of each variable was determined using a histogram and the Shapiro-Wilk normality test. For the descriptive statistics of each variable, normally distributed variables were expressed as mean ± standard deviation, whereas non-normally distributed variables were presented as median (interquartile range). To assess the validity of KOJI AWARENESS™, we compared the NRS score using Pearson correlation coefficients. In addition, we performed a partial correlation analysis with BMI, sex, and age as control variables (23, 24). The correlation was considered "strong" if $r \geqq 0.5$, "medium" if $0.5 > r > 0.3$, or "weak" if $0.3 > r > 0.1$ (25).

RESULTS

None of the subjects were excluded after entry, and no participants withdrew their consent. The types of sports and their numbers were as follows : athletics, 14 ; basketball, 7 ; handball, 5 ; judo, 3 ; rugby, 2 ; boxing, 1 ; kendo, 1 ; speed skating, 1 ; skiing, 1. The KOJI AWARENESS™ and NRS scores were 39.8 ± 6.3 and 5.0 (4.5), respectively. The KOJI AWARENESS™ and NRS scores for each location of pain are shown in Table 1. The pain locations and their numbers were as follows : upper limbs, 4 ; back, 5 ; thigh,3 ; knee,8 ; ankle, 7. The KOJI AWARENESS™ score showed a strong negative correlation with the NRS score for pain intensity during daily training ($r = -0.640$, $P < 0.001$) (Figure 1). The results of simple and partial correlation analyses with BMI, sex, and age as control variables are presented in Table 2. There was a significant negative correlation between KOJI AWARENESS™ and NRS scores, even when BMI, sex, and age were entered as control variables.

Table 1. The KOJI AWARENESS™ and NRS score for each location of pain.

	KOJI AWARENESS™		NRS	
Location of pain, Number	mean	SD	mean	SD
No pain, 8	43.38	3.74	0.00	0.00
Upper limbs, 4	36.50	3.87	6.25	0.50
Back, 5	37.29	8.60	5.71	2.29
Thigh, 3	44.67	3.51	4.00	1.00
Knee, 8	39.50	5.42	5.00	2.07
Ankle, 7	37.80	7.63	5.00	1.58

NRS; numerical rating scale.

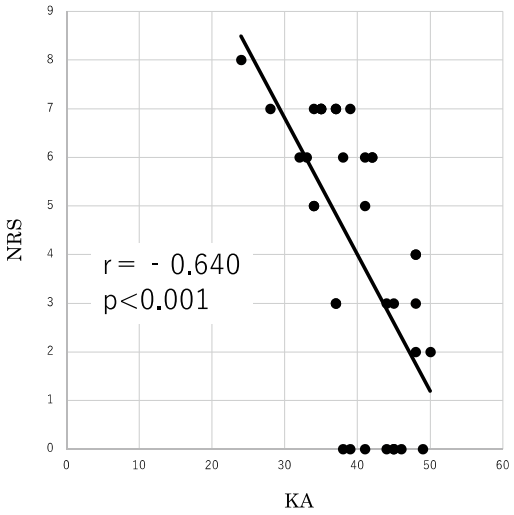

Figure 1. Correlation between KOJI AWARENESS™ and NRS scores (N = 35). NRS, Numerical Rating Scale.

Table 2. Simple and partial correlation analyses between KA and NRS (N = 35).

	KA[a]		Control variables
	r value	p value	
NRS[†]	-0.664	p<0.001	None
NRS[a]	-0.484	0.004	BMI
NRS[a]	-0.617	p<0.001	Gender
NRS[a]	-0.641	p<0.001	Age
NRS[a]	-0.507	0.003	BMI, gender and age

[†]The Simple correlation between the KA and NRS was calculated by Pearson's correlation analysis.
[a]The partial correlation between the KA and NRS was calculated by Pearson's correlation analysis.
KA, KOJI AWARENESS™ ; NRS, Numerical Rating Scale ; BMI, body mass index.

DISCUSSION

The purpose of this study was to investigate the relationship between pain intensity among athletes during their daily training and the total points scored on KOJI AWARENESS™ in order to determine whether body dysfunction is related to pain among athletes. The results indicated a strong negative correlation between KOJI AWARENESS™ scores and athletes' pain during their daily training. Furthermore, there was a strong negative correlation between KOJI AWARENESS™ and NRS scores when age, sex, BMI, and athlete status were analyzed as control variables.

Several studies have investigated the validity of functional screening tests for pain intensity. Soltandoost Nari and Shamsoddini (26) reported that the Functional Movement System (FMS) score and pain severity of non-specific chronic low back pain (NCLBP) in male military personnel were negatively correlated ($P = 0.04$, $r = -0.285$). According to these authors, the FMS could be a functional assessment tool for identifying functional deficits in military personnel with NCLBP. Present study supports the idea that body dysfunction is related to pain.

In contrast, a previous study showed no significant association between body movement function and pain. Vogel *et al*. conducted functional movement analysis (FMA) in patients with chronic low back pain (CLBP) (27). FMA consists of 11 standardized motor tasks applied from a daily living movement that can differentiate the movement patterns of healthy individuals from those of people with CLBP. The results of a previous study (27) indicated no significant association between the sum score of FMA and pain intensity ($r = 0.06$, $P = 0.980$). Furthermore, the study population showed low pain levels and low scores for kinesiophobia and disability (27). On the other hand, the population in the current study exhibited a significant negative correlation with pain. We assumed that this discrepancy in results between studies was attributable to differences in medical conditions, age, exercise history, and screening tools between studies. In the previous study (27), low physical activity was limited to people with CLBP, which we believe explains the differences in the results of our investigation.

Vogel *et al*. hypothesized that active people with CLBP do not change their movement behavior as strongly as inactive people (27). We also hypothesized that athletes are less fearful of moving their bodies even in uncomfortable situations and push further than those with less exercise history. Therefore, the relationship between body function and pain can be more relevant for athletes ; nonetheless, further investigation is required.

As pain in athletes is a contributing factor to poor performance, daily monitoring of KOJI AWARENESS™, which is related to pain, may provide insight into the athletic performance of athletes. Alkatan *et al*. (28) reported that exercise interventions can reduce pain and improve muscle strength and motor function. Therefore, KOJI AWARENESS™ may be used as a scale to test the effectiveness of exercise interventions. Appropriate interventions for athletes with underestimated KOJI AWARENESS™ scores may improve their scores and lead to a decrease in pain. Motor function evaluation with KOJI AWARENESS™ in athletes who do not complain of pain may enable the prediction of pain appearance in the future. To clarify this, cohort studies should be conducted.

The current study has some limitations. First, the subject population included in this study may not be representative of all athletes. The age of participants was mostly under 30 years ; thus, the study does not provide data for older people. Second, as the present study was a cross-sectional study, it is unclear whether KOJI AWARENESS™ is affected by future injuries. Additionally, because this study was not an intervention study, it also remains unclear whether improvements in KOJI AWARENESS™ scores lead to improvements in pain. In the future, it will be necessary to analyze changes in KOJI AWARENESS™ through intervention studies and cohort studies with a wider range of subjects.

In conclusion, the self-screening test, KOJI AWARENESS™, was significantly correlated with pain intensity in athletes during their daily training. KOJI AWARENESS™ may be useful as a motor function assessment tool related to pain in athletes.

CONFLICT OF INTEREST

The authors certify that there are no conflicts of interest with any financial organization regarding the material discussed in the manuscript.

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Appendix 1. 11 component movement test.

Appendix 1

KOJI AWARENES™

1, Neck Mobility

1 point

L: 1 point, R: 1 point

L: 1 point, R: 1 point

1 point

2, Shoulder Mobility

L: 1 point, R: 1 point

3, Shoulder Blade (Scapular) Mobility

L: 1 point, R: 1 point

3

4, Thoracic Spine Mobility

1 point

2 point

3 point

4

5, Upper Extremity Stability & Strength

10 sec 10 sec 10 sec

1 point 2 point 3 point

3 sec

5 sec

3 sec

4 point

5

L: 1 point, R: 1 point

L: 1 point, R: 1 point

Flex Internal and External Rotation

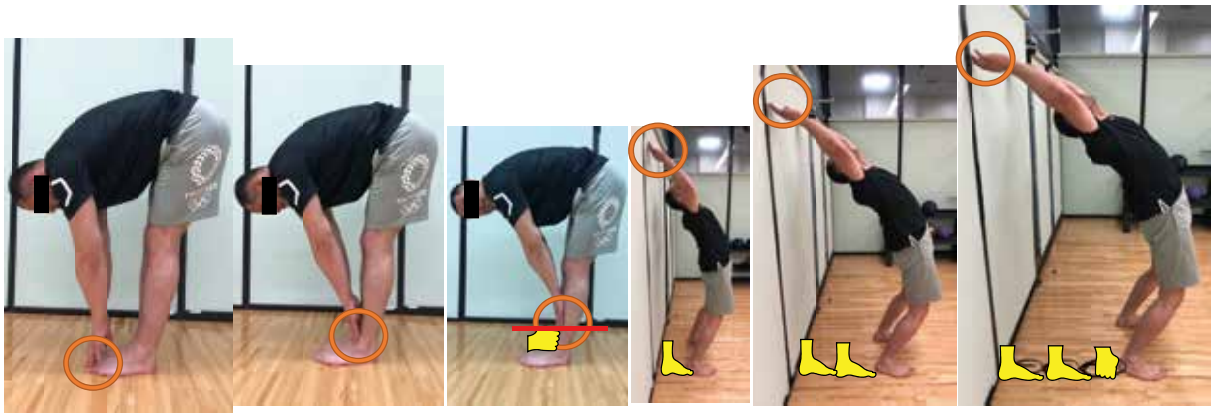
6, Hip Mobility

L: 1 point, R: 1 point

L: 1 point, R: 1 point

Extend Internal and External Rotation

7, Hip and Spine Mobility



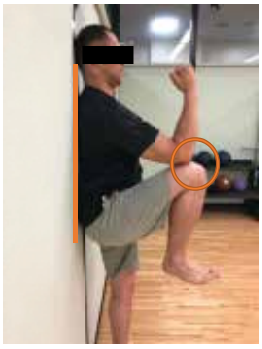
3 point 2 point 1 point 1 point 2 point 3 point

7

8, Upper and Lower Extremity Mobility and Stability

3 sec L: 1 point, R: 1 point

Clearing Test



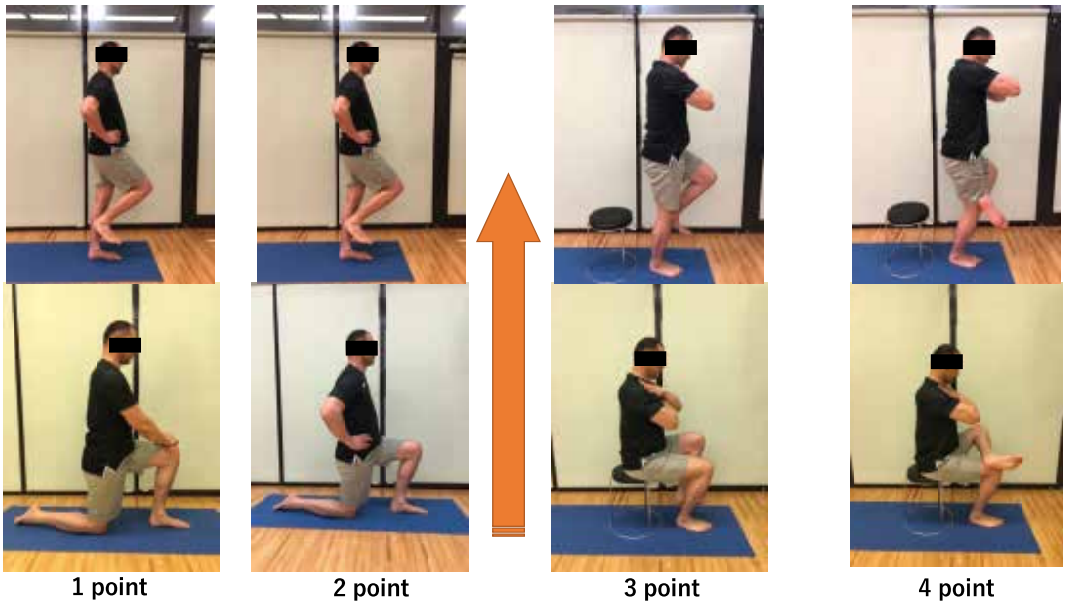
8

9, Mid-section Stability Strength

1 point 2 point 3 point 4 point

9

10, Lower Extremity Strength



1 point 2 point 3 point 4 point

10

11, Ankle Mobility

11

L: 1 point, R: 1 point

Scoring Chart Sheet

Name (sports, organization, record, gender, DOB)			DATE	1	2	3	4
KOJI AWARENESS			TOTAL	**SCORE**	**SCORE**	**SCORE**	**SCORE**
Check 1: Neck Mobility (Total 6 Point)		Front	1				
		Back	1				
		Left	1				
		Right	1				
		Right Rotation	1				
		Right Rotation	1				
Check 2: Shoulder Joint Mobility (Total 2 Point)		Left	1				
		Right	1				
Check 3: Scapular Mobility (Total 2 Point)		Left	1				
		Right	1				
Check 4: Thoracic Spine Mobility (Total 6 Point)		Left	3				
		Right	3				
Check 5: Upper Extremity Stability & Strength (Total 4 Point)			4				
Check 6: Hip Mobility (Total 8 Point)	Flex/ER	Left	1				
		Right	1				
	Flex/IR	Left	1				
		Right	1				
	Ext/ER	Left	1				
		Right	1				
	Ext/IR	Left	1				
		Right	1				
Check 7: Hip and Spinal Mobility (Total 6 Point)		Front	3				
		Back	3				
Check 8: Trunk and Lower Extremity Mobility & Stability (Total 2 Point)		Left	1				
		Right	1				
Check 9: Trunk Strength (Total 3 Point)			4				
Check 10: Lower Extremity Strength (Total 8 Point)		Left	4				
		Right	4				
Check 11: Ankle Mobility (Total 2 Point)		Left	1				
		Right	1				
Total Score (50)			50	0	0	0	0

Appendix 2. Scoring criteria.

Appendix2	**Scoring Criteria**		
Components	**→ Set Up →**	**→ Move →**	**criteria**
①Neck Mobility [FRONT]	stand in front ofamirror	bring the chin toward the chest	1 point : he/she can touch the chest with his/her chin 0 point : he/she can NOT touch the chest with his/her chin
[SIDE]	stand in front of a mirror with hands on the waist, set elbows in a straight line when viewed from the top	tilt the head to one side	1 point : he/she can tilt the midline of the face parallel to the upper arm 0 point : he/she can NOT tilt the midline of the face parallel to the upper arm
[ROTATION]	stand sideways in front of mirror with hands on the waist, setelbows in a straight line when viewed from the top	rotate the head without moving the shoulders	1 point : he/she can tilt the midline of face parallel to the shoulder 0 point : he/she can NOT tilt the midline of face parallel to the shoulder
[BACK]	lie on elbows and knees with fingertips at a 4-foot length away from wall	look up to the wall	1 point : he/she can see 2-elbow height mark on wall without difficulty 0 point : he/she can NOT see 2-elbow height mark on wall without difficulty
②Shoulder Mobility	stand with the back of a hand on the lower back	reach toward the opposite shoulder blade	Touch the inferior angle of the blade
③Shoulder Blade (Scapular) Mobility	stand in front of mirror with fingertips holding the opposite earlobe	move the arm around the head and back	1 point : he/she can arch the arm to go around the head without head tilt 0 point : he/she can NOT arch the arm go around the head without head tilt
④Thoracic Spine Mobility (3 levels)	Level 1 : sit 2 knuckles away from the wall with knees together, hands on shoulders with elbows in a straight line when viewed from the top	rotate body to reach toward the wall with an elbow	1 point : he/she can touch wall with an elbow while knees are together 0 point : he/she can NOT touch wall with an elbow while knees are together
	Level 2 : sit 2 knuckles away from the wall with knees together	rotate the body to reach toward wall with the opposite hand	1 point : he/she can touch wall with handsby the shoulder while knees are together 0 point : he/she can NOT touch wall with hands by the shoulder while knees are together
	Level 3 : sit 2 knuckles away from the wall with knees together, hands on opposite shoulders, set elbows at shoulder height	rotate body to reach toward the wall	1 point : he/she can touch the wall with the upper arm between the shoulder and elbow while knees are together 0 point : he/she can NOT touch wall with the upper arm between the shoulder and elbow while knees are together
⑤Upper Extremity Stability & Strength (4 levels)	Level 1 : create the front hand-plank position on the wall, feet at 4-foot lengths away from the wall, hands shoulder width at eye level	Hold the plank position for 10 seconds	1 point : he/she can hold the position for 10 seconds while the head, pelvis, ankles are in line 0 point : he/she can NOT hold the position for 10 seconds while the head, pelvis, ankles (knees for Level 2)are in line
	Level 2 : create the front hand-plank position on floor with bent knees	hold plank position for 10 seconds	
	Level 3 : create the front hand-plank position on the floor	hold plank position in different conditions	
	Level 4 : start with the front hand-plank position, then perform the side hand-plank followed by the same on the opposite side.	hold the plank position for 5, 3,and 3 seconds, respectively	1 point : he/she can hold each position while the head, pelvis, and ankles are in line 0 point : he/she can NOT hold each position while the head, pelvis, and ankles are in line
⑥Hip Mobility [FLEXION/ER]	stand in front of the wall, 1 foot & 1 knuckle away, keep a knee on the wall with the thigh parallel to the floor	rotate the leg to the inside, touch the ankle	1 point : he/she can touch the medial malleolus without tilting the torso 0 point : he/she can NOT touch the medial malleolus without tilting the torso
[FLEXION/IR]	stand in front of the wall, 1 foot & 1 knuckle away, keep a knee on the wall with the thigh parallel to the floor	rotate the leg to the outside, touch the ankle	1 point : he/she can touch the lateral malleolus without tilting the torso 0 point : he/she can NOT touch the lateral malleolus without tilting the torso
[EXTENSION/ER]	bend the knee toward the buttocks while standing on one leg, keep the knees together	rotate the leg to the inside, touch the ankle	1 point : he/she can touch the medial malleolus without tilting the torso 0 point : he/she can NOT touch the medial malleolus without tilting the torso
[EXTENSION/IR]	bend the knee towards buttocks while standing on one leg, keep the knees together	rotate the leg to outside, touch the ankle	1 point : he/she can touch the lateral malleolus without tilting the torso 0 point : he/she can NOT touch the lateral malleolus without tilting the torso

⑦Hip and Spine Mobility (3 levels) [FRONT]	Level 1 : stand with feet shoulder width apart, mark at knuckle length from the ankle	bend over to reach the mark	1 point : he/she can touch one knuckle above the ankle 0 point : he/she can NOT touch one knuckle above the ankle
	Level 2 : stand with feet shoulder width apart	bend over to reach the ankle joint	1 point : he/she can touch the ankle joint 0 point : he/she can NOT touch the ankle joint
	Level 3 : stand with feet shoulder width apart	bend over to reach the toes	1 point : he/she can touch the toes 0 point : he/she can NOT touch the toes
[BACK]	Level 1 : stand 1-foot length away from wall with the back facing the wall	touch wall with hands over the head	1 point : he/she can touch the wall from 1-foot length away 0 point : he/she can NOT touch the wall from a 1-foot length
	Level 2 : stand 2-foot length away from wall with the back facing the wall	touch wall with hands over the head	1 point : he/she can touch the wall from a 2-foot length 0 point : he/she can NOT touch the wall from a 2-foot length
	Level 3 : stand 2-foot and 1 knuckle length away from the wall with the back facing the wall	touch the wall with hands over the head	1 point : he/she can touch the wall from 2-foot and 1 knuckle length away 0 point : he/she can NOT touch the wall from 2-foot and 1 knuckle length away
⑧Upper and Lower Extremity Mobility & Stability	stand with feet shoulder width apart	bring one side of the elbow and knee together	1 point : he/she can hold the elbow and knee together without tilting the torso for 5 seconds 0 point : he/she can NOT hold the elbow and knee together without tilting the torso for 5 seconds
[CLEARING TEST] : cannot get 1pt for component 8 without passing this test.	stand with the back against the wall, heels 1 knuckle away from the wall	bring one side of the elbow and knee together	PASS : he/she can touch the elbow and knee while the back of the head and opposite upper and lower back stay on the wall FAIL : he/she can NOT touch the elbow and knee while the back of head and opposite upper and lower back stay on the wall
⑨Mid-section S tability & Strength (4 levels)	Level 1 : lie on back on the floor with knees bent, arms straight by the torso	bring shoulder blades away from the floor	1 point : he/she can hold the shoulder blades away from the floor for 5 seconds 0 point : he/she can NOT hold the shoulder blades away from the floor for 5 seconds
	Level 2 : lie on the back on the floor with knees straight, arms straight by the torso	bring shoulder blades away from the floor	
	Level 3 : lie on the back on the floor with knees straight, hands on opposite shoulders	bring shoulder blades away from the floor	
	Level 4 : lie on the back on the floor with knees straight, hands on back of head	bring shoulder blades away from the floor	
⑩Lower Extremity Strength (4 levels)	Level 1 : Sit in a half kneeling position, hands in front of the knee	stand up and sit down using hands	1 point : he/she can stand up and sit down without losing control 0 point : he/she can NOT stand up and sit down without losing control
	Level 2 : Sit in a half kneeling position, hands on the waist	stand up and sit down	
	Level 3 : Sit on a chair, with one leg off the floor, hands on opposite shoulders	stand up and sit down with one leg	
	Level 4 : Sit on a chair, with legs crossed, hands on opposite shoulders	stand up and sit down with legs crossed	
⑪Ankle Mobility	toe 1 knuckle away from the wall while in a half kneeling position	bring the knee to the wall	1 point : he/she can touch the wall by the knee without lifting the heel 0 point : he/she can NOT touch the wall by the knee without lifting the heel

For Component 4, 5, 7, 9, and 10, measure Level 1 exam first, then go on to the next level if he/she passes it. The score is based on the level that was passed. If the level cannot be completed, the section is terminated at that point. If he/she can't pass Level 1, he/she get 0 points.