Infrared Sensor Technology (IST) Test as a Tool for Assessment of Flexibility

A – preparing concepts
B – formulating methods
C – conducting research
D – processing results
E – interpretation and conclusions
F – editing the final version

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Abstract

Introduction: The evaluation of flexibility is important to coaches to assess their players' flexibility status, predict future performance, and even detect talented players. The aim of this research was to develop a new flexibility test to examine the forward split in athletes.

Material and methods: In this study, 15 gymnasts, 10 Taekwondo athletes, 5 football players, and 10 karate athletes (20 males and 20 females) volunteered for this experiment and were evaluated in a common movement pattern, the forward split. In the experimental condition, participants performed the forward split on a mattress using infrared sensor technology (IST test), and, afterward, they performed the forward split on a mattress without infrared sensor technology (N-IST test). Two trials of this procedure were conducted.

Results: For concurrent validity, no significant difference in the average distances of the anterior superior iliac spine (ASIS) from the mattress in Trials I and II was found between the IST and N-IST tests — $p = 0.664$ and $p = 0.710$, respectively.

Conclusions: The findings of this study confirm the concurrent and construct validity of the IST test, which was created to measure the height of the ASIS from the mattress in a forward-split test. Thus, this test can be used by coaches, athletes, and sports scientists to improve and monitor the forward-split tests of athletes in training programs.

Key words: **muscle, athletes, sit and reach, parallax error, sports technology**

Introduction

Exercise and training is an important component used to help an athlete achieve their optimal performance [1]. In the process of improving an athlete's performance using exercise there is a risk of musculoskeletal injury [2]. Flexibility is an important factor for successful performance [3]. Previous studies have identified that adequate flexibility is important in both the prevention and rehabilitation of musculoskeletal injuries [4].

Several studies have shown that the exercise method can be an important factor for increasing muscle flexibility in athletes. Kibar et al. observed an eight-week Pilates training program and found it to have a beneficial effect on static balance, flexibility, abdominal muscle endurance, and abdominal and lumbar muscle activity [5]. Previous research conducted by Kathleen et al. explained that the use of a roller-massager could provide statistically significant increases in flexibility, particularly when used for a long duration [6].

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Thus, evaluation of flexibility appears to be important for coaches to evaluate their players' flexibility status, predict future performance, and even detect talented players. According to Wells and Dillon, the sit-and-reach test is a common measure of flexibility, and it specifically measures the flexibility of the lower back and hamstring muscles [7]. Although the sit-and-reach test specifically measures the flexibility of the lower back and hamstring muscles, it is unclear whether this style of test could be performed to assess flexibility in the forward split. Therefore, maybe we should adopt new technologies and new variables for measuring flexibility, especially in the forward split.

An interest and motivation behind this study was to add a new test for assessing flexibility in the athlete. Specifically, this study was interested with a previous research conducted by Loureiro Jr. et al., who created and developed a new agility test encompassing both perceptual and motor capacity, and an examination of the test's concurrent and construct validity and its test–retest reliability in badminton players, and it was named the 'Badcamp test' [8]. Despite the differences between variable measurements (agility and flexibility), a similar purpose to created new technologies is a concept rather than this research. To the best of the authors' knowledge, there is no test that measures specific flexibility in the forward split. Based on the aforementioned problems and interests, the aim of this research was to develop a new flexibility test to examine the forward split in athletes.

Material and methods

In this study, 40 athletes, 15 gymnasts, 10 Taekwondo athletes, 5 football players, and 10 karate athletes, (20 males and 20 females) volunteered to be assessed on their ability to perform the forward split. All of the participants were asked to fill out a health questionnaire, and they gave their informed consent to participate in this study. All the procedures were approved by the ethics committee of the Makassar State University, and the experimental procedure was performed in accordance with the Declaration of Helsinki. The players were between 18 and 20 years old, and they had a minimum continuous training background of five years. Additionally, all athletes must have participated in systemized training, with at least two training sessions per week, each lasting 3 hours. None of the subjects had lower- and upper-extremity injuries or musculoskeletal injuries within six months prior to the initial testing.

Testing setup

The infrared sensor technology (IST) test was performed on a rectangular mattress (8-cm thickness and 2 × 1 m in size). At the centre of the split area was an infrared sensor, placed 4 cm inside the mattress, that provided vertical displacement detection (SHARP GP2Y0A41SK0F distance measuring sensor, 4 to 30 cm). Connected to the infrared sensor was a microcontroller (microchip, model Arduino Uno Atmega328p) programmed in C++ language to measure the height of the anterior superior iliac spine (ASIS) from the mattress. An automatic light-emitting diode (LED) panel displayed the results.

The apparatuses used in the IST test could be considered low cost and efficient for coaches or sports practitioners. The whole apparatus could be built or obtained for less than US$200. Furthermore, the IST test apparatuses could be easily transported and quickly assembled (approximately 15 min) anywhere. The IST is displayed in Figure 1.

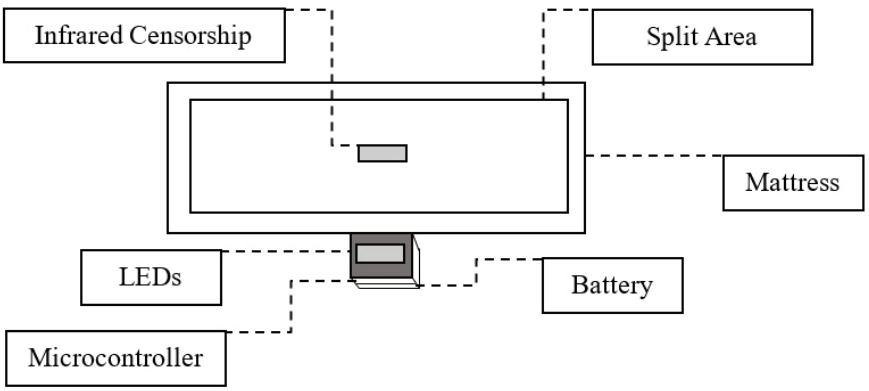

Fig. 1. Infrared sensor technology

Experimental overview

The week before the study was performed anthropometric measurements were obtained. Anthropometric characteristics of the participant's data are shown in Table 1.

Tab. 1. Anthropometric characteristics of participants

Variable	Female (N = 20)	Male (N = 20)
Age (years)		
X̄ (SD)	17.65 (±0.75)	17.80 (±0.77)
Weight (kg)		
X̄ (SD)	59.04 (±6.0)	70.56 (±6.06)
Height (cm)		
X̄ (SD)	164.23 (±6.13)	170.93 (±8.87)
BMI (kg/m²)		
X̄ (SD)	21.89 (±1.81)	24.24 (±2.35)

The test was performed at a gymnasium of Makassar State University. The test was divided into two trials, separated by 30-min recovery periods. It was ensured that the participants were wearing the compression garments (CGs). The CGs used in the test were Sport-Skins Classic whole-body CGs from Skins, Campbelltown, NSW, Australia. The lower-body CGs included long-leg pants (from waist to ankle) composed of 24% ROICA spandex and 76% nylon and Meryl Microfiber [9]. Additionally, sports shoes commonly used in practice sessions were worn by the participants during the testing.

Before testing, all athletes performed a standardized 6-min warm-up period. After the warm-up, participants performed the forward split on the mattress with IST (the IST test), and afterward they performed the forward split on the mattress without IST (the N-IST test): Trial I. A 5-min rest interval was given to the participants between the performance of the IST and N-IST tests. After Trial I, a 30 min recovery was given before the athlete could perform the forward split in Trial II.

Forward split

The forward split was performed following a previously reported procedure [10]. The test was explained and demonstrated step by step to the participants by the experimenter. The participant was asked to start with their dominant leg. In the IST test, the test started when the participant was ready and had placed their body in the split area of the mattress. First, the participant was instructed to place the rear leg shank against the vertical side of a gymnastics spotting block. It was assumed that, if the rear leg was placed in this position, it could reduce the variability of the pelvic position as the athletes lowered to their lowest split position. Additionally, this test position helped maintain a pelvis position that kept the frontal plane of the pelvis perpendicular to the line of the forward and rear legs of the forward split. When the participant achieved the lowest split position, the participant gave warning signals, saying 'maximal', and then automatically the infrared sensor controlled the height of the ASIS from the mattress. The administrator noted the results from the LED display. The test ended when the participant finished the lowest split position.

For the N-IST test, participants performed on the mattress without IST. The same protocol for the forward split of the IST test was repeated in the N-IST test. The difference between the N-IST and IST tests was the measurement protocol. In the N-IST test, when the participant achieved the lowest split position, the participant gave warning signals, saying 'maximal'. Then, the administrator palpated the ASIS of the participant and measured the height of the ASIS from the mattress using a meter stick. The forward split test position in IST and N-IST tests is displayed in Figure 2.

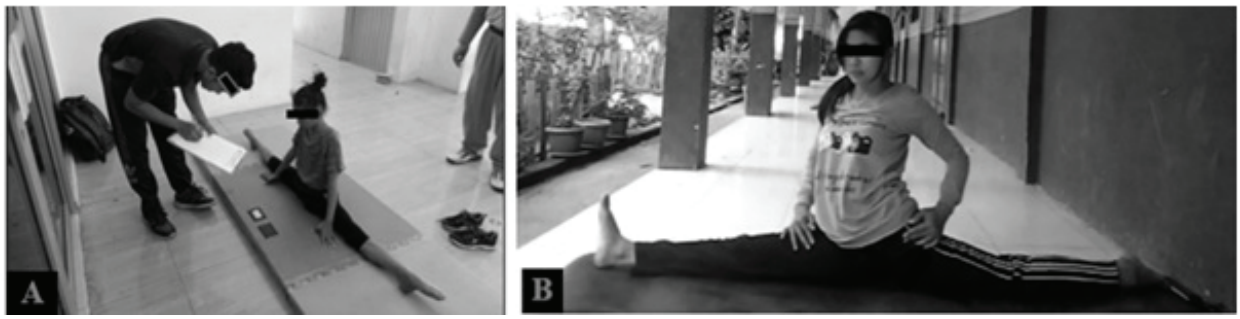

Fig. 2. (A) Forward split test position in IST test and (B) forward split test position in N-IST test

Statistical Analysis

The values are presented as mean ± SD. A Mann–Whitney U test was used to determine significant or no significant differences between the IST and N-IST tests in two trials. Statistical significance was accepted at the $p < 0.05$ level. The tests were performed by using the SPSS software V.21.0.

Results

Table 2 shows the measurements of the height of the ASIS from the mattress in the N-IST and IST tests. For concurrent validity, no significant difference in the average distances of the ASIS from the mattress in Trial I was found between the IST and N-IST tests ($p = 0.664$). Similar results were found in Trial II, where there was no significant difference between IST and N-IST tests ($p = 0.710$). Furthermore, no significant differences ($p = 0.721$) were observed between the averages of all trials of the IST and N-IST tests.

Tab. 2. Performance distances of participants in IST and N-IST tests

	Height of the ASIS from the mattress (cm)		p-value
	IST test	N-IST test	
Trial I			
$\bar{X}$ *(SD)*	4.7 (± 3.3)	4.8 (± 3.3)	
Median	4.0	4.0	0.664
Range	0.8 – 11.8	1.0 – 12.0	
Trial II			
$\bar{X}$ *(SD)*	4.5 (± 3.0)	4.6 (± 3.1)	
Median	3.0	4.0	0.710
Range	0.8 – 11.8	1.0 – 12.0	
Average of All Trials			
$\bar{X}$ *(SD)*	4.6 (± 3.1)	4.7 (± 3.2)	
Median	3.9	4.0	0.721
Range	0.8 – 11.7	1.0 – 12.	

Abbreviations:

The values are presented as mean ± SD.

IST, forward split on mattress with infrared sensor technology; N-IST, forward split on mattress without infrared sensor technology; Trial I, measured height of the ASIS from the mattress in first trial; Trial II, measured height of the ASIS from the mattress in second trial; Average All Trials, average of N-IST tests in Trials I and II compared with the average of the IST tests in Trials I and II

Discussion

An attempt was made to develop and examine the specificity of the IST test for the flexibility assessment of athletes. This study showed that measurements in the IST test are strongly related to the measurements by the meter stick. The results of this study showed no significant difference between the IST and N-IST tests. In the study, the meter stick was used as a tool for manual measurement and for comparing the level of similarity of reliability and validity with the IST test. The meter stick was used because this method was considered to have the appropriate reliability and validity to measure the distance; also, the method is often used to measure the forward split. Previous research conducted by William et al. measured the forward-split test in two conditions (vibration and no vibration) using a meter stick, and they used the meter stick for measuring the height of the ASIS from the floor [10].

This study revealed that the sports technology investigated should be created to evaluate an athlete's performances. The evaluation of an athlete's performances is important for increasing and developing the performances of athletes [11]. Several studies have found that sports technology can be used to evaluate an athlete's performance. Loureiro Jr. et al. found a Badcmap test to evaluate agility in badminton athletes, and they explained that the Badcamp test is an effective, valid, and reliable tool to measure agility. The Badcamp test showed that this field test can be used by sports scientists, coaches, and athletic trainers to assess the athletic condition and training effectiveness of badminton players [12].

To the authors' knowledge, coaches or sports scientists have always used a meter stick to measure the height of the ASIS from the mattress in the forward-split test. This method results in a phenomenon that can be a problem. The problem is the parallax error. Parallax error is an error caused by humans while measuring a quantity if the eye is not at the proper angle to the scale of the reading [13]. Because of this problem, the IST was developed to assess flexibility, especially to measure the height of the ASIS from the mattress in the forward-split test and to prevent the parallax error. That is possible because the values are read from the LED display. To the authors' knowledge, there is no digital-based test that evaluates and measures the height of the ASIS from the mattress in the forward-split test. These facts support the notion that the IST provides an accurate test for the forward-split test.

This study has limitations that should be considered. Young athletes with ages between 17 and 19 years were tested. The results could have

been different if professional and/or high-level athletes had been evaluated. Therefore, further research using differing subject populations with differing levels of performance is warranted.

Conclusion

The findings of this study confirm the concurrent and construct validity of the IST test, which was created to measure the height of the ASIS from the mattress in a forward-split test. Furthermore, it was shown that the IST test is a valid and reliable instrument to assess flexibility, especially in the forward-split test. Thus, it is recommended that this test be used by coaches, athletes, and sports scientists to improve and monitor training programs in the forward-split testing of athletes.

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