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Discussion

The aim of this thesis was to develop a novel device that is capable of diagnosing sarcopenia among older people. We rely on the four steps of EWGSOP2 algorithm which essentially require STS time and the power developed while performing STS. The device was designed as an instrumented chair in order to fulfil three objectives (i) to determine whether various instrumented versions of the STS are preferable to non-instrumented versions of the STS with respect to prediction of physical functions, (ii) to follow up with an evaluation of the suitability of STS as a functional screening test which could be further used to screen for other parts of sarcopenia diagnosis based on the EWGSOP2 algorithm, (iii) to develop and validate an instrumented version of the STS using a chair that is able to identify different phases of the STS test and to predict muscle strength and power.

First one was successfully achieved, with a systematic review presented in Chapter 2, identifying the benefits of an iSTS when compared to stand STS tests in which only the time taken to perform the test (5STS) or the number of STS cycles completed (30STS) are used as performance measures. It is clear, from this piece of work, that the emergence of the instrumented STS is an area with great potential to improve the detection of strength-related conditions such as physical frailty, and to assess the risk of falling in older people. The parameters extracted from the iSTS were better able to differentiate between groups of fallers and different frailty levels than the time taken for the STS alone. The key improvement that is needed in this area is to standardise the segmentation of the STS into phases so that results can be compared more easily between studies. Clearly, the best results were obtained for a study in which four force plates were incorporated into a chair, including two in front under the feet of the person being tested [Houck et al, 2011]. It was logical, therefore, to consider to integrate force sensors into the chair directly in a cheaper and portable alternative to the force plates. In addition, the standardisation of STS protocols was also recommended. This is in keeping with the recommendation of a recent systematic review of the manually timed version of the 5STS, with several recommendations for the protocol to be followed [Mehmet et al, 2019]. These included testing participants twice with 30 seconds between tests, no practice test, and using the fastest time. They also recommended starting the test in the seated position, by stopping the test after the fifth sit-to-stand transition, in other words after 4.5 STS movements.

Encouraging results were obtained in order to fulfill the second objective, that is, to assess the suitability of the STS as a measure of physical performance in the EWGSOP algorithm (severity). A classification study on an imbalanced data set provided satisfactory results using machine learning techniques after applying resampling methods.It is likely that better results would be obtained if a larger data set is used, especially, if it is balanced between cases and controls.

Third and final objective of this thesis was to develop and validate an instrumented version of the STS using a chair that could measure STS time, identify the different phases of the STS test and to predict muscle strength and power. These objectives were attained and presented in Chapters 5, 6 and 7. The first of these two studies showed that the iSTS chair could accurately measure STS time compared to an expert, with better performance than three other instrumented versions of the STS using a force plate, the Kinect sensor, and a standard RGB camera. In addition, to STS time, the iSTS chair was also better than the other three systems at estimating STS velocity. The second study was able to identify six phases of the STS movement by using fusion between the iSTS chair and an RGB camera. Although, this was a successful approach, still it requires simultaneous use of two system so in next study only the iSTS chair with ultrasonic sensor designed which is able to detect phases of STS even when subject was not in direct contact with chair.

The work of this thesis is considered in light of the EWGSOP2 algorithm. With respect to the Assess criteria, the iSTS Chair was able to accurately determine STS time, meaning that it satisfies the EWGSOP2 algorithm. The results for the Severity criteria were also good, although potential for improvement exists by testing more participants in a balanced data set, and also using iSTS parameters to improve accuracy due to the close link with gait velocity. Finally, the Confirm criteria was only partially fulfilled as, although the iSTS Chair can accurately determine lower-limb muscle power, a study in which muscle mass is measured is needed for confirmation that the entire algorithm can be met in this single device. A muscle mass measurement study was outside the scope of this thesis, but given that the power results were as good as that of Takai [Takai et al, 2009], it is likely that the muscle mass results would be as good as Takai, a correlation of r=0.80.

The idea of using an instrumented chair for STS evaluation was a novel idea when this thesis began. It has advantage over other instruments as it doesn't require any sensor mounted in the body of subject tested and we can use iSTS chair for any attire since its tough to measure lower limb muscle strength using Isokinetic dynamometer when subject wearing saree (Indian attire for ladies). Since this time, a number of new research teams have also begun to investigate this possibility. For instance, an automatic chronometer was placed on the seat to enable different phases of the STS to be timed [Collado-Mateo et al, 2019]. In some cases, multiple methods have been combined. For instance, a Kinect camera was combined with an IMU on a belt, with participants standing on a force plate during the test [Hellmers et al, 2019]. Indeed, in two recent studies the entire SPPB was instrumented [Bai et al, 2018, Jung et al, 2019]. In the second of these studies, a device similar to that developed in this thesis was presented, using force sensors in a chair and a position sensor to determine the position of the person being tested from the back of the chair [Jung et al, 2019]. The idea of determining the position of the person being tested from the chair forms part of the future work envisaged in the development of the iSTS Chair.

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