

RELIABILITY OF THE DAID SMART SHIRT FOR SHOULDER GIRDLE MOTION ASSESSMENT IN HIGH STRING PLAYERS

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Abstract. Smart garment system is efficient for upper body movement monitoring during simple tasks. There is a lack of literature on smart textile garments being reliable for shoulder girdle motion assessment in advanced motor tasks such as high string performance. The aim of the article was to examine the reliability of the DAid Smart Shirt for Shoulder Girdle Motion Assessment during advanced motor tasks such as high string performance. Methods: 14 volunteer violinists aged 18.6 (SD 2.1) with a body mass index 20.05 (SD 2.3) were recruited. The violinists performed a legato bowing task. The DAid smart shirt worked as the assessment tool: a compression garment with textile strain sensors sewn onto it. Cronbach alpha coefficient, Interclass Correlation Coefficient were calculated to assess the within-session test-retest reliability. Results: An excellent and good result test-retest reliability was assessed in 57% of the violinists, for other 43%, the ICC and Cronbach alpha coefficient was less than 0.59. Conclusion: the DAid Smart shirt is reliable for shoulder girdle motion assessment during high string performance. The smart textile garment should be customized and suitable for the body in order to assess shoulder girdle motion during high level or advanced activities such as high string performance.

Keywords: high string performance, shoulder motion monitoring, smart Garments.

Introduction

Musculoskeletal complaints are a frequent, serious and potentially career threatening problem among professional musicians (Kok, Huisstede, Voorn, Schoones, & Nelissen, 2015). The majority of professional musicians suffer from

musculoskeletal complaints affecting their ability to play their instrument (Kok et al., 2015, Kok, Schrijvers, Fiocco, van Royen, & Harlaar, 2018).

Playing high strings like the violin or viola requires an asymmetrical posture and repetitive movements. These two facts are most likely the key contributing factors to PRMD (Performance-related musculoskeletal disorders) in high string players (Horvath, 2010; Blanco-Pinheiro, Di'az-Pereira, Marti'nez, 2015; Schemmann, Rensing, & Zalpour, 2018). In a recent systematic review, the year-prevalence of musculoskeletal complaints in professional musicians ranged between 41% and 93% (Kok et al., 2015).

String musicians have musculoskeletal disorders in 79.6% of the cases and the most frequently affected body parts are shoulders, especially the right side (59.6%) (Abreu-Ramos & Micheo, 2007). In reaction to shoulder pain or in order to unload painful structures, there is a tendency to develop altered movement patterns; this could be observable as shoulder girdle compensatory movements: elevation, upward rotation (Wang et al., 2017). In case of shoulder pain, altered muscle activity is observed, including delayed activation of affected muscles, redistribution of the muscle activity within a muscle as well as redistribution to the synergistic muscles (McCrary, Halaki, & Ackermann, 2016). Correction and assessment of an altered movement pattern is essential in the rehabilitation of shoulder pain (Wang et al., 2017).

A smart garment system is efficient for the upper body movement assessment during simple tasks (Wang, Markopoulos, Chen, & Timmermans, 2017) and the designed DAid Smart shirt can be an objective and convenient device for shoulder motion capture and monitoring during advanced motor tasks such as shoulder motor control exercises and ballet training sessions (Semjonova, Vetra, Oks, & Katashev, 2018). There is lack of sufficient literature on smart textile garments being reliable for shoulder girdle motion assessment in advanced motor tasks such as high string performance.

This study aims to examine the reliability of the DAid Smart Shirt for shoulder girdle motion assessment during advanced motor tasks such as high string performance.

Methodology

The study was designed as an observational experimental study in which all participants were tested by the same observer. Prior to participation, all participants were fully informed about the complete intervention task.

Participants were recruited on a voluntary basis through a researcher from Rehabilitation faculty, Riga Stradins University, Riga, Latvia, and by contacting the director of the Emils Darzins Music School. There were 14 volunteer violinists recruited, the average age 18.6 (SD 2.1) with 3.6 hours as the self-reported playing

hours per day on average (SD 0.7). The violin size was 4/4 (n=12), 7/8 (n=2). The average Body Mass Index indicated was 20.05 (SD 3.2). The body mass index (BMI) was calculated from self-reported weight (kg) and height (m) according to the guidelines of the WHO (World Health Organization) Regional office for Europe (<https://www.who.int/>).

Instrumentation: the DAid Smart shirt was used to assess shoulder girdle motion in the participants during the research task. This smart garment was developed in collaboration between Riga Technical University and Riga Stradins University and with the purpose of posture assessment (Semjonova et al., 2018). The DAid Smart shirt represents a tight shirt with four embedded highly sensitive knitted strain sensors (Oks, Katashev, & Litvak, 2014). Sensor reactions are transferred via sewn electro-conductive lines to an electronic device acquiring data, and then sent via Bluetooth to a computer or tablet. A specific sensor placement provides independence of the sensor reactions to the patient's shoulder elevation-depression movements. ADC 1 – left side shoulder elevation; ADC 2 – right side shoulder elevation; ADC 3 – right side shoulder protraction; ADC 4 – left side shoulder protraction (Fig. 1).



Figure 1 DAid Smart shirt with named sensors

The intervention task given to participants was a legato bowing task. The metronome was set to 100 bpm and each bowing covered 4 beats. The subject kept playing until at least 10 complete bowings were acquired. Three repeated intervention measures (Ancillao, Savastano, Galli, & Albertini, 2017) with the DAid Smart Shirt were performed (Fig. 2.).

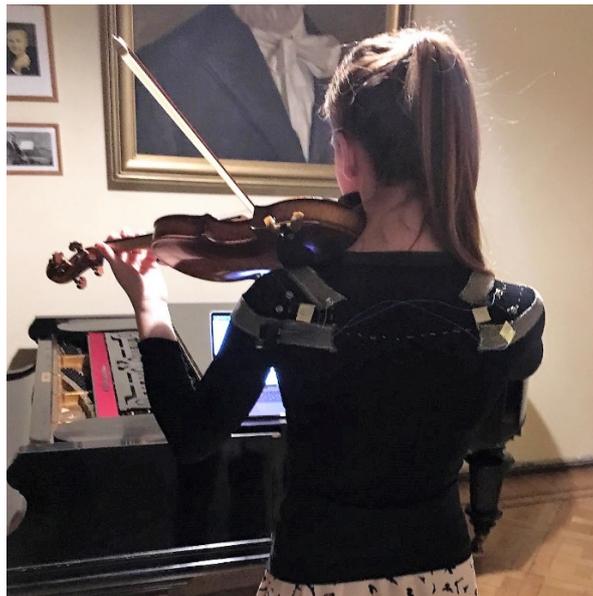


Figure 2 Participant with DAid smart shirt during intervention

Methods for statistical data analysis: descriptive statistical analysis was carried out to describe the study population. To assess the within session test-retest reliability for repeated measure units (mV) during the task, the Cronbach α coefficient, Interclass Correlation Coefficient (ICC) in SPSS Statistics 22.0 (IBM Corporation, New York, USA) were calculated. Variables were the values of the DAid Smart Shirt in millivolts (mV).

Ethical Statements: participants provided informed consent in a written form for inclusion prior to their participation in the study. The study was conducted in accordance with the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee of Riga Stradins University (183/26.01.2017).

Results

One DAid Smart Shirt was used for all participants, it was not customized and tailored for each individual body. Participants were divided into groups according to their body mass index (BMI) with a small difference ($SD < 0,5$): the BMI of the participants in the 1st group ($n=4$) was 19.3 ($SD 0,2$) – normal weight; the BMI of the participants in the 2nd group ($n=4$) was 20.9 ($SD 0,5$) – normal weight. For both of these groups, the DAid smart shirt was size fitting. The BMI of the participants in the 3rd group ($n=3$) was 23.8 ($SD 0,5$) – normal weight, but the DAid smart shirt was overstretched. The BMI of the participants in the 4th group ($n=3$) was 17.4 ($SD 0,5$) – underweight, the DAid smart shirt was too large for their body size.

Only the data from the ACD2 sensor – right shoulder elevation – were analysed. The ACD1 sensor data were not suitable for analysis; there were interaction artefacts between the left shoulder, the sensor and the violin.

After three repeated measures, the results of the first group where the DAid smart shirt was size fitting show excellent values of the ICC and Cronbach’s α coefficient. ICC values: 0.80 (95%CI 0.78-0.81) – 0.89 (95%CI 0.88-0.90) ($p < 0.0001$). Cronbach’s α coefficient values: 0.80 – 0.89. The data from the ACD 2 sensor – right shoulder elevation – show the lowest and the highest repeated measure values (mV) during intervention as similar (Fig. 3, Fig. 4, Fig. 5).

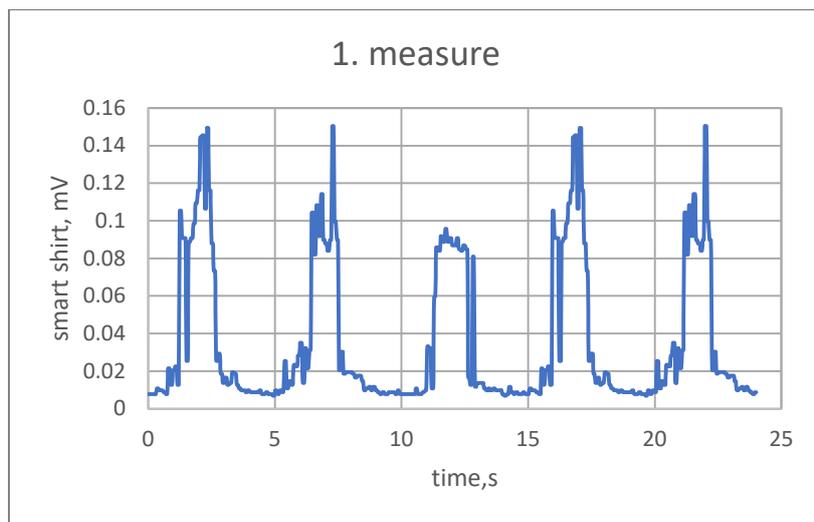


Figure 3 ACD 2 sensor 1st measure data

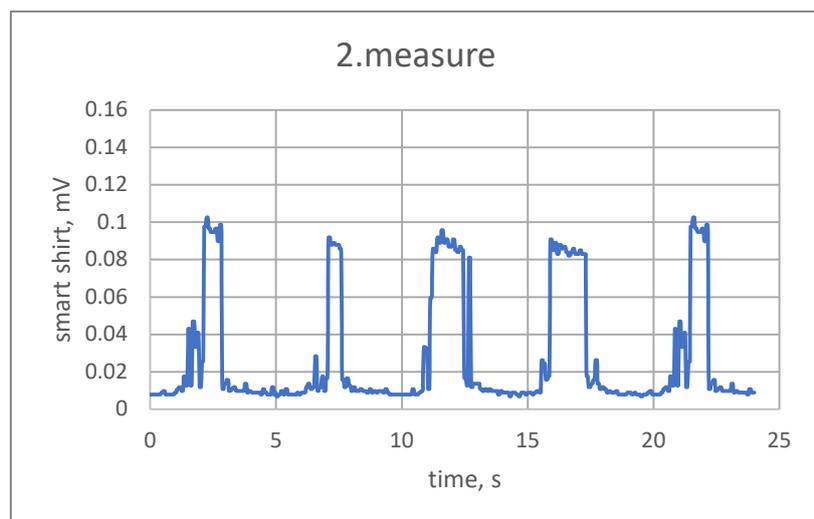


Figure 4 ACD 2 sensor 2nd measure data

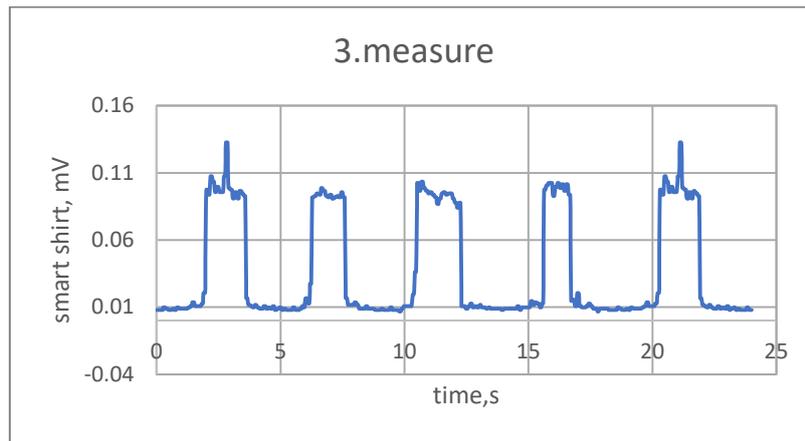


Figure 5 ACD 2 sensor 3rd measure data

The results of the second group show good ICC and Cronbach's α coefficient values. ICC values: 0.61 (95%CI 0.58-0.63) – 0.70 (95%CI 0.68-0.72) ($p < 0.0001$). Cronbach's α coefficient values: 0.61 – 0.70.

The results of the third group show fair ICC and Cronbach's α coefficient values. ICC values: 0.41 (95%CI 0.37-0.45) – 0.57 (95%CI 0.54-0.60) ($p < 0.0001$). Cronbach's α coefficient values: 0.41 – 0.57.

The measuring results of the fourth group show poor ICC and Cronbach's α coefficient values. ICC values: 0.17 (95%CI 0.16-0.95) – 0.39 (95%CI 0.35-0.43) ($p < 0.0001$). Cronbach's α coefficient values: 0.17 – 0.39. Within this group, the DAid smart shirt measure values were unpredictable (Fig. 6).

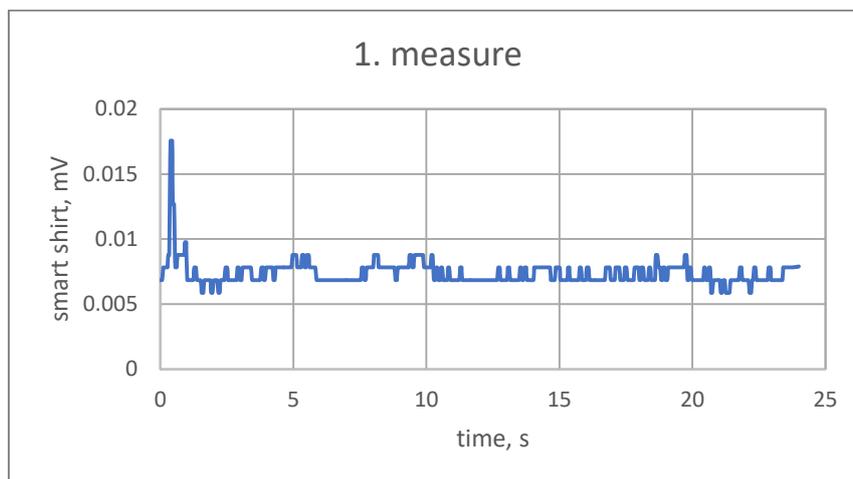


Figure 6 ACD 2 sensor measure within 4th group

Discussion

This study was performed to examine the reliability of the DAid Smart Shirt for shoulder girdle motion assessment during advanced motor tasks such as high string performance. The present study revealed that the DAid Smart Shirt should be customized and suitable for individual body types. If the smart shirt is size fitted, then test-retest reliability after three repeated measures shows excellent ICC and Cronbach's α coefficient values for the right-side shoulder. Another aspect that was also highlighted in the systematic review by Wang et al is that the sensor should be placed in the right location on the body for high accuracy and reliability (Wang et al., 2017).

Playing high strings is a physically highly demanding task (Ancillao et al., 2017), especially for the upper part of the body (Horvath, 2010). For example, in the sports industry when training during advanced motor tasks the load quantification, assessment and evaluation of physical, physiological and technical conditions in real time is of paramount importance for the development of the athlete and the prevention of injuries (Mendes et al., 2016). The recent study and development of rehabilitation technologies creates new possibilities for therapists and patients to support the process of learning a musical instrument or the rehabilitation process after injuries.

Future studies are needed to improve the evaluation of left shoulder movement with sensors in high string performance. The sensor should be able to interact only with the body under the sensor, not with the musical instrument. Also, it would be necessary to evaluate these wearable devices over an extended period of time, in rehabilitation settings in case of a shoulder pain patient, during advanced motor tasks and within therapy sessions.

Several limitations apply to this study. First, the DAid smart shirt was only a one-sized compression garment with sewn textile strain sensors. Second, a small number of participants were involved. Third, the DAid Smart Shirt was not suitable for left shoulder movement assessment, since there was an interaction between the shoulder, the smart shirt and the violin.

Conclusion

The present study shows that the DAid Smart shirt is reliable for the motion assessment of the right-side shoulder girdle during high string performance.

The smart textile garment should be customized and suited for the body type in order to assess the motion of the right-side shoulder girdle during high level or advanced activities such as high string performance.

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Conflicts of Interest: The authors declare no conflict of interest.

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