Reimagining Design of Golf Clothing: Addressing the Asymmetrical Pose

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Abstract

One factor that can impact performance and comfort of athletes is clothing design. For many sports, the athlete performs a set of extreme movements that can be impeded or made uncomfortable because of clothing that does not accommodate such movements. The objective of this research is to create body forms in active positions to assist in the development of golf clothing for the active body. A Human Solutions Vitus Smart XXL body scanner was used to scan five professional golfers at different stages of a golf swing. Half scale dress forms in the active position were then prepared using these scans. The half scale forms developed in the golf swing pose are an effective design development tool to create golf clothing optimized for fit on the active figure. Wear tests and visual fit evaluations of prototype garments developed on these forms were conducted, comparing their fit and performance to when in a squatting pose and through the golf swing with the active pants developed in this research. As professional young golfers, all five participants stated that the idea of active pants and enhancing comfort through motion is as an important challenge to address.

Keywords: 3D body scanning, fit models, half scale dress forms, active body pose, golf clothing

1. Introduction

High levels of competition in world-class sports force athletes to continuously explore means of improving their performance [1]. One factor that can impact performance and comfort of athletes is clothing design. For many sports, the athlete performs a set of extreme movements that can be impeded or made uncomfortable because of clothing that does not accommodate such movements. One design strategy for creating effective active wear for athletes is to create clothing optimized for the active position instead of the neutral standing position [2]. Most of the current design methods that address active positions do not consider the 3D body effectively. In a recent research project, Vuruskan and Ashdown (2017, 2015) investigated design and fit evaluation methods using 3D body capture of the active cycling position. The researchers created dress forms for design development and fit evaluation of bike shorts designed for the active position [3,4]. They experimented to discover effective methods for 3D body capture in the cycling position and for reconstruction of the body in a reliable way. Half scale dress forms developed from these scans were used as fit evaluation tools, where the 3D body form in the active pose has been the main input instead of linear body measurements.

The objective of this next stage of the research in design for active bodies is to create active body forms to assist in the creation of golf clothing that is designed to be comfortable throughout the golf swing. Golf wear has been the focus of several research projects in the past. Lee and Kim (2002) conducted design research on golf wear considering the style, colour, material and trim development [5]. Following a needs assessment survey, Chae and Evenson (2014) realized prototype golf wear design for mature female golfers, in which they discovered that some of the most critical issues for female golfers in their clothing design were free movement, comfort, fit, and sun protection [6]. As is true for most research in the design of golf clothing the garments created in this study were created in the standing pose, with design features such as pleats introduced in an attempt to accommodate movement. In our research, design of golf clothing is considered from another perspective by introducing 3D body scanning and half scale dress forms in the active body pose; and using these tools for better fitting clothing through the golf swing. Unlike cycling, movements performed by golfers are asymmetrical, therefore requiring garments designed for either a left or right handed golfer. In addition to 3D body scanning and half scale mannequin production of the asymmetrical body in a golf swing position, pattern making and garment production practices also include asymmetry, which was introduced as a new concept for golf clothing in this research.

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2. Methods and Procedures

2.1. 3D body scanning and production of half scale dress forms

The participants in the study consisted of five professional golfers, who were chosen to provide a range of body types and sizes. A Human Solutions Vitus Smart XXL body scanner was used to scan the golfers at different stages of a golf swing, and in the standing position. More occlusions and data loss can occur when scanning the body in active poses, compared to standard standing poses. Therefore, various trials were conducted in order to identify the best scanning procedures. Efforts concentrated on minimization of data loss while obtaining a valid body form in the golf swing pose. To minimize areas of missing data, alternative orientations of the body to the cameras were tested.

After obtaining scans with sufficient data points in the golf swing poses, the scan data were augmented using 3D software tools. Figure 1 illustrates 3D scan images and processed digital files of active golf swing poses. The native software ScanWorX from Human Solutions was used to create a triangle mesh of the scan and the file was imported into Geomagic Studio to create 3D digital models. Besides data cleaning, the missing areas in the body were manually patched using the Geomagic software. 3D digital bodies were made ready for the production of half scale dress forms of the lower body in the active position. The lower body was modeled as the research concentrated on the fit of golf pants for the active position.

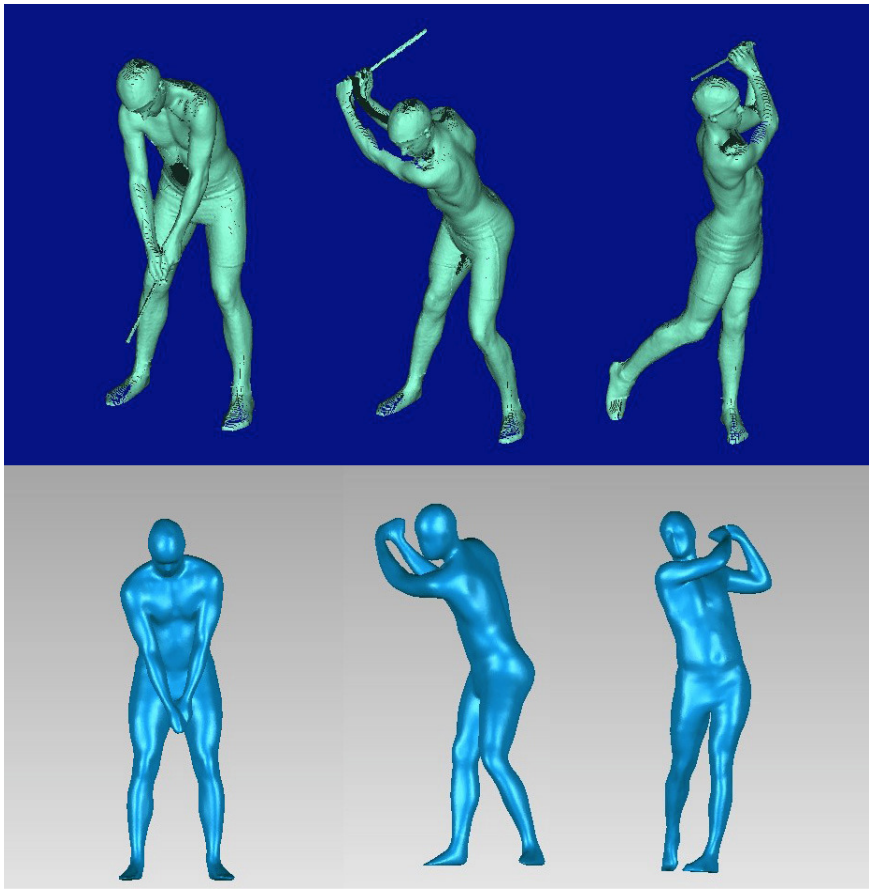

Fig. 1. 3D body scans and processed digital files of active golf swing poses

Various other experiments were conducted in another round of scanning, using a hand held scanner. A Structure Sensor, a handheld scanner that uses a combination of infrared and laser light sources was used to capture a full body image. Similar to previous scans, missing areas could be patched with 3D digital tools for a watertight digital model. 3D digital images obtained with the structure scanner were promising with a good number of data points acquired to create the half scale forms (see figure 2). However, since all participants in this research were available to be scanned with the Human Solutions scanner which captures a more reliable scan in a shorter time, data with the Structure sensor was not used for this part of the research and a standard scanning process using the Human Solutions scanner was utilized for all five participants in the research.

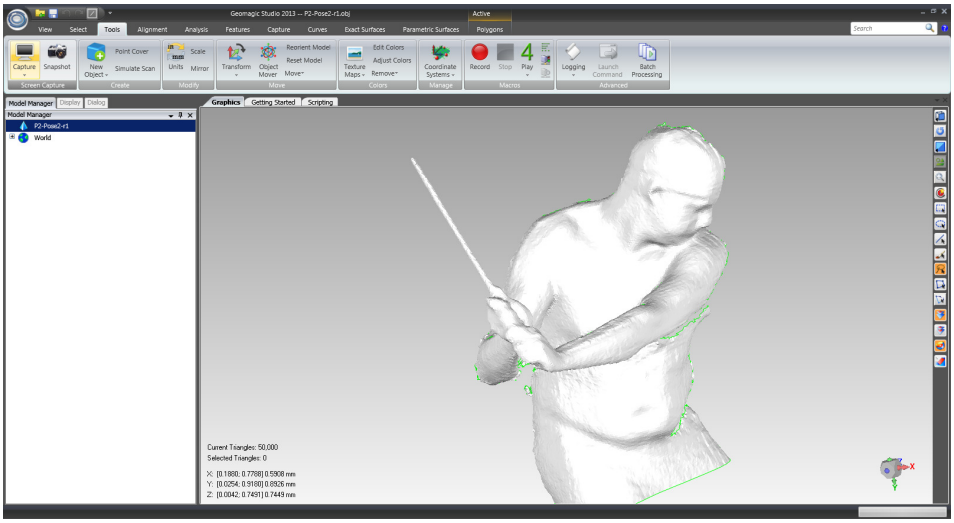

Fig.2. 3D body scans obtained from the hand held structure scanner in the golf swing pose

Dress forms in the active position were then prepared using the processed scans. In order to save space, materials, and time, these forms were created in half scale. Among various poses that were scanned through the golf swing, the end of the back-swing was selected for the production of half scale dress forms, as this portion of the golf swing is the most extreme. All participants in this research, who are professional golfers, claimed that this pose has the most importance to the effectiveness of the golf shot, and therefore would require the highest level of comfort. Since golf pants were selected as the garments to be designed in this initial study, half scale dress forms were prepared from chest to knee level (see figure 3). This body section of the digital form was sliced into cross sectional layers with registration holes and notches using Polyworks software. The DXF files were transferred to Adobe Illustrator and all cross sections were cut using a laser cutter. Slices were carefully stacked on dowels by matching the notches in order to prevent shifting and were glued together. The form was covered with a knit fabric. The median line of the body was marked on both the front and back of the form, along with the waist.

The back-swing scan pose of a participant and the half scale form is seen in figure 3. Half scale dress forms were prepared both in this pose and in the standing pose for all five participants in order to develop patterns and for fit testing of half scale prototypes.

Fig. 3. Half scale form developed from the scan in the golf swing pose

2.2. Pattern making, prototype production and fit tests

Half scale dress forms in the asymmetrical pose were used for pattern development of customized golf pants by applying draping techniques (see figure 4). Considering the asymmetry of the pose, pattern pieces were draped independently on both sides of the body, and then joined in the center front and center back.

Fig. 4. Draping golf pants on half scale dress forms

Drape patterns were trued in 2D using pattern making tools and half scale prototype pants were produced in muslin. A series of pattern adjustments and iterations of prototype pants were realized, until a satisfactory fit was obtained for both the standing and active posed half scale dress forms. Patterns were then scaled up for the production of full-scale golf pants.

A project collaboration was established with a golf clothing brand for the manufacturing of the customized prototype golf pants. In addition to these pants, standard RTW (ready-to-wear) golf pants from the same brand and same type of golf pants were provided by the company, which were selected for comparative testing according to the participants' sizes.

After the production of the pants, individual fit tests were conducted by comparing both pants in various poses, such as sitting, squatting and through a full golf swing, as well as the standing pose. A final wear test was additionally conducted for comparative feedback from the participants, judging the fit and performance of the prototype pants and the RTW pants while playing golf.

3. Results and Discussion

3.1. 3D body scanning in the active body pose

In this research, effective methods for 3D body capture in the golf swing position and development of digital models using these scans were explored. Compared to standard scanning positions, the scans of the participants in active positions resulted in more missing data caused by occlusion from cameras that are placed to optimize data capture of a standard body position. However, missing areas could be reliably patched using 3D digital tools. In the golf swing pose, the most extensive patching issue was seen in the chest area, around the shoulders and under the arms, areas that are occluded from the cameras by other body parts. After patching and preparing watertight digital forms, dress forms could be produced for the design development and fit testing. Scanning of active poses allowed development of customized mannequins for the asymmetrical golf swing pose.

Half scale mannequins developed from 3D active body forms in the golf swing pose provided the base for pattern development, where the 3D body shape and the asymmetrical pose could be directly transferred to 2D patterns.

3.2. Developing tools from digital models for design and fit testing of apparel

Precisely scaled dress forms are a novel concept in apparel for pattern creation and fit testing. Unlike traditional half scale forms used in apparel development, the half scale forms made from scans are an exact duplicate of the fit model, scaled down to precisely half their size. Patterns developed on these half scale forms when digitized and scaled up show promise as a methodology to create well-fitting patterns in less time and with less material use than when using full scale forms.

In contrast to standard dress forms, half scale forms prepared for the back-swing pose were asymmetrical, and therefore required draping on both sides of the body. Pattern pieces for right and left side of the body showed the differences required in order to provide comfort throughout the motion. In order to develop a garment in the asymmetrical pose, changes in the dimensions obtained in the active pose are incorporated into the design of the 2D pattern. Developing the pattern directly from the half scale active form allowed a perfect transition of the 3D body shape into the pattern design. Both the active forms and the standing forms assisted the fit development of the patterns by providing models for fit testing of iterative prototypes. It is important that the pants have acceptable fit in the standing position, while optimizing the fit in the active position, so that they will be acceptable to the golfers throughout the day; not only when the golfer is hitting the ball. Having both forms allowed the modification of the pattern through the series of prototype pants in the half scale to arrive at the correct balance of fit between the two body postures.

3.3. Fit evaluations

All five participants had different sizes and body shapes, which was a deliberate selection. Initial fit evaluations, which were realized with each participant in sitting, standing, squatting positions and through the golf swing, helped to adjust any outstanding fit issues in the RTW and in the active parts (see figure 5). The RTW pants were adjusted to a more custom fit so that they would have fit similar to the custom made active pants. Participants also provided feedback on their active pants by responding to a questionnaire and through discussion with the researchers.

Fig.5. Fit tests of golf pants in various poses

Since the garments were asymmetrical, participants stated that they found the pants extraordinary because they didn't look like any other pants that they had ever worn. They discussed the fact that they were not used to wearing asymmetrical pants; however, they all were interested in trying the pants on while playing golf. Even though they are asymmetrical, participants' first reactions were not negative regarding the look of the pants. Side seam lines were not straight in the standing position; but this did not have a negative effect on the participants.

For all participants there was more space in the crotch in the active pants in comparison to the RTW pants which allowed freedom in movement. Participants stated that they were satisfied with the fit mostly in the squatting pose and through the golf swing in the active pants.

The level of satisfaction of the participants with the active pants was higher in the golf swing pose than in the standing pose. However, as professional golfers, participants expressed willingness to sacrifice the look of the pants in the standing position to some extent, in order to have more comfortable pants while in motion.

Participant 1 stated that he was more comfortable with the active pants while squatting (for example, to view the green) than in the RTW pants. He claimed a positive attitude regarding the look and the feel of the pants from the middle thigh downward, where the seam lines were rotated to optimize fit in the golf swing pose.

Two images of participant 1 are given in figure 6, with his customized half scale forms, and when he is testing the fit and function of the active pants.

Fig. 6. Participant with prototype pants developed on the half scale form, with his active and standing half scale forms

Participant 2 claimed that he felt very satisfied with the active pants through the full golf swing and while squatting. A moderate level of fit satisfaction was provided in the standing pose. He assessed his satisfaction level of the active pants higher than that of the RTW pants. Additionally, in discussion with the researchers, he expressed his satisfaction with the active pants throughout the full golf swing, as they provided a level of fit not experienced in any other pants that he had. He underlined that those pants had a little more range of motion and this is a valuable criterion for performance.

Participant 3 evaluated the fit of active pants higher in the sitting and squatting positions. However, he found the RTW pants more satisfactory while standing.

Participant 4 evaluated the active pants with good fit through the full golf swing in all parts of the lower body (waist, hip, crotch, thigh, calf, length). He claimed the highest level of satisfaction in the golf swing pose, and a good level of satisfaction in all other poses. His ranking with active pants included higher comfort level in the golf swing pose than RTW pants.

Participant 5 assessed a satisfaction level higher in the golf swing pose for active pants than RTW pants. However he marked the fit of the active pants with a lower rank for the standing pose.

Participants were also satisfied with the fit of RTW pants; however, after the wear tests while playing golf outdoors, participants stated that the idea of active pants and enhancing comfort through motion is an important challenge. Having positive feedback from the participants, who were young professional golfers, was also a valuable motivation for further development of such garments in this project.

The wear testing stage of this research is ongoing. Early results indicate that there is not a high level of acceptance of the active pants over the RTW pants. However, reasons for this were sometimes related to factors unrelated to the pant silhouette, such as a difference in pocket size between the active pants and the RTW pants, or to small unintended variations in fit, such as calf dimension. More rigorous prototype development is needed to produce a set of active pants appropriate for field testing.

4. Conclusions

Full body scanning in the active body pose by using traditional scanners and the concept of half scale body forms in the active pose was a challenge in this research. Despite the problems in capturing data in 3D body scanning of active poses, it was seen that even for complex active poses it is possible to create an accurate 3D data point cloud. The key point is to identify the set-up most suitable for a particular active position with the minimum of shadowing, thus minimizing data loss. Utilization of generic software for further manipulation of 3D digital models can be used to improve the scan data in active body forms. Employing other strategies such as the use of a hand held scanner to capture the missing data points could also be integrated into the process.

3D active body forms in the golf swing pose, which were developed in this research, may have the potential to provide valuable insights for garment design, pattern construction and fit assessments both for ready-to-wear sizing and customization. The half scale forms are effective design development tools to create golf clothing optimized for fit on the active figure. The asymmetrical pose helps to reflect the exact pose and 3D shape of the body to the garment. Besides, such a form is more appropriate for fit testing since it represents the golf swing pose more reliably.

In order to be accepted by golfers the garments designed for the active position must facilitate active positions, but must also look appropriate when the golfer is in a neutral position. Other factors affect marketability, including whether selling garments in left and right hand options is feasible.

Despite much research using body scanners, limited data exist on the body in active poses, and the creation of forms in active body positions. Use of these tools for design development and fit testing of activewear is a new concept. Developing clothing patterns in an asymmetrical way is an alternative approach for active body poses. Methods developed in this research can be used for sportswear design in active body positions for other sports.

The next stage of this research will be to further refine the patterns using knowledge from the fit testing and wear testing of the pants on the five participants. The perfected patterns will then be compared to look for common features among the patterns. A set of RTW patterns in a full size range will be developed based on common features of the prototype pants. Golf pants made from these patterns will be fully tested by a larger participant group, both in fit testing and wear testing.

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