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RESEARCH

The Interacting Effects of Men's Height and Shoulder-to-Hip Ratio on Comfort Distance: A Virtual Reality Study

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Abstract

Objectives Previous studies have shown that body size and height affect one's perceived optimal distance during social interactions. This current study is built up on the previous research that found a relationship between men's height and comfort distance but failed to find any effect of men's shoulder-hip ratio (SHR) on one's comfort distance. The current study investigated the combined effect of SHR and height to eliminate methodological issues that prevented from establishing an effect of SHR in the previous study.

Methods In this study, a total of 49 participants (both men and women) reported their comfort distance in relation to 63 male avatars that differed in height from 150 to 190 cm (9 values) and in SHR from 1 to 1.3 ratio (7 values).

Results and Conclusion The result of this study showed that both genders had an increment of their comfort distance as the height of the avatar increased. The effect of SHR on comfort distance was only evident with extreme SHR measurements; demonstrating that height is a better indicator of establishing comfort distance during interactions.

Keywords Height · Shoulder to hip ratio · Comfort distance · SHR · Virtual reality

Similar to any other species, humans prefer an optimal range of distance for their interactions with their counterparts (Hall, 1966; Hayduk, 1983). This preferred interpersonal distance can vary in relation to multiple variables and situations, such as sex, age, facial expressions and attractiveness, body shape and body size (Cartaud et al., 2018; Hammes, 1964; Iachini et al., 2016; Pazhoohi et al., 2019b; Rapuano et al.,

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2021; Ruggiero et al., 2017; Yee & Bailenson, 2007). In general, the comfort distance of individuals increases in certain threatening situations; especially when interacting with agents with higher social status and/or dominance. (Coello & Cartaud, 2021; Felipe & Sommer, 1966; Hall, 1966; Sundstrom & Altman, 1976).

One bodily factor influencing comfort distance for interactions is human height. Taller individuals more frequently violate personal space of shorter individuals (Caplan & Goldman, 1981), and pedestrians are more likely to yield to taller persons than to shorter ones, potentially due to higher social status of taller individuals (Stulp et al., 2015). Previous research has linked height to higher social status and dominance (Ellis, 1994; Stulp et al., 2013; Sorokowski, 2010). Accordingly, recent proxemics studies have shown that individuals prefer larger distances from taller avatars in virtual reality (Pazhoohi et al., 2019b), and reducing one's height in VR simulations increases social anxiety and paranoia (Freeman et al., 2014).

Another bodily trait affecting human optimal distance in social interaction is body size. Larger body sizes in animals and humans are linked to higher dominance, fighting ability and social status (Ellis, 1994; Parker, 1974; Sell et al., 2012). Proxemics research has also demonstrated an association between body size and comfort distance for social interactions, indicating people have larger comfort distances from larger individuals during these social communications (Buck et al., 2022; Caplan & Goldman, 1981; D'Angelo et al., 2019; Ruggiero et al., 2019; Sakata et al., 2017). However, for the most part, height and body size have not been disentangled in the previous research and they are often used interchangeably in proxemics studies. A similar confound between height and body size is evident in the attractiveness research (e.g., Sell et al., 2017). One explanation might be that height and upper body size are traits that are developmentally correlated and might be subjected to correlational selection (Fink et al., 2007; Hill et al., 2013). However, it need not follow that both factors are relevant. For instance, the combined effect might be equivalent to one factor alone, with the other factor having a negligible impact.

Indeed, no previous research, save for recent studies conducted by Pazhoohi and colleagues (2019b, 2022), has considered height and upper body size separately. Specifically, in a virtual reality study, the authors investigated the separate effects of male height and upper body size (indicated by the shoulder-to-hip ratio or SHR) by fixing one trait and manipulating the other (i.e., creating five versions of male avatars differing in height and a fixed SHR, and another five differing in SHR with a fixed height). In this way Pazhoohi et al. (2019b) found that male height but not SHR had an effect on comfort distance. It is tempting to conclude from this that SHR has no effect, even when it is varies with height, although this was not tested directly. The importance of this possible limitation was recently driven home by Pazhoohi and colleagues (2022) investigation of the separate *and combined* effects of male height and SHR on women's perceptions of men's attractiveness, masculinity, and fighting ability. Their results revealed that women's perceptions of men's attractiveness, masculinity, and fighting ability were influenced by height and SHR, as well as their interaction. This latter finding points to the potential design limitation in Pazhoohi et al. (2019b).

To address this issue, the current study examined if height and SHR, when combined, influence the comfort distance for interaction in a social context with men in virtual reality. Participants indicated their comfort distance from sixty-three male avatars differing in height (9 values) ranging from 150 to 190 cm and SHR (7 values) ranging from 1.00 to 1.30 ratios.

Method

Participants. A total of 49 university students (17 men and 32 women) aging between 18 and 35 years (M=20.84, SD=3.46) participated in the current study. A total of 30 participants (61.2%) reported being single, and 34.7% reported being in a relationship. Additionally, two individuals (4.1%) reported being married.

Stimuli. A male avatar was generated using Daz3d software (www.daz3d.com). A total of 63 stimuli were created by systematically manipulating the male avatar, in height (9 values) and SHR (7 values) (see Fig. 1). The heights of the models ranged from 150 to 190 cm; and each model had a height increment of 5 cm from the previous one. This height range estimation was based on the reports that concluded that the average universal height of men ranged from below 160 cm to over 180 cm (Perkins et al., 2016; Roser et al., 2013). Also, the models differed in their SHR, ranging from 1.00 to 1.30, incrementing in 0.05. One previous investigation has indicated an average of 1.18 ± 0.07 for male adult SHR (Hughes & Gallup, 2003). The combination of nine different heights and seven different SHRs resulted in a total of 63 stimuli for this study (Fig. 1).

Procedure. Initially, participants were asked to fill out the demographic and the consent form. Once both forms were filled in, the participants were taken to the testing room where the VR headset was secured on their head and they were given a hand controller to navigate the VR environment. We used an HTC Vive Pro head-mounted display with two HTC SteamVR base stations, version 2.0, in addition to the hand-held controller. The computer driving the HTC Vive Pro contained a 4.0 GHz Intel i7 6700 K CPU equipped with 16GB RAM and an Nvidia GeForce GTX 1080 graphics card.

During testing participants were randomly presented with each of 63 different stimuli that were randomly situated at one of two initiating distances (1 and 3 m)

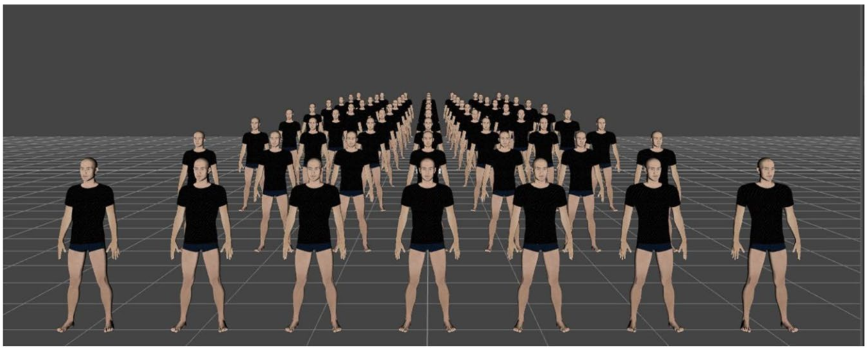

Fig. 1 Sixty-three avatars differing in height on y axis (9 values) and SHR on x axis (7 values) used in this study

from the participants. Note that each stimulus image was presented once at one starting distance and one at the other distance (see Fig. 2 for an example of the actual image). Participants used the VR controller to change the distance between each model and themselves to estimate their own personal comfort distance when interacting with men of different body structures (Height and SHR). Once confident in the selected comfort distance, the participants pressed the trigger on the controller to confirm their decision and move on to the next trial of the study. Each participants completed a total of 126 trials (63 stimuli × 2 initiating distances).

Results

A 2 (Participant Sex) × 7 (SHR) × 9 (Height) mixed ANOVA was performed with Participant Sex as a between-subjects variable and SHR and Height as within-subjects variables. All post hoc comparisons reported here, and throughout the results, were done using Bonferroni correction, and this is also reflected in the *p* values. The main effects of SHR and Height were significant (see Table 1 for details). There were no significant interactions.

Post-hoc comparisons for SHR showed that participants preferred a larger comfort distance from stimuli with a 1.25 SHR ($M = 1.51$, $SEM = 0.14$, 95% CI [1.23, 1.79], $p = .008$) and a 1.30 SHR ($M = 1.53$, $SEM = 0.15$, 95% CI [1.24, 1.83], $p = .015$) compared to a 1.00 SHR ($M = 1.44$, $SEM = 0.13$, 95% CI [1.17, 1.70], Fig. 3).

Fig. 2 Example of scene, model and instruction as was presented to participants

Table 1 Mixed ANOVA Main and Interaction Effects Results for Comfort Distance as a Function of Sex, Height, and SHR

Predictor	df_{num}	df_{den}	F	p	partial η^2
Sex	1	47	1.02	0.317	0.02
Height	8	376	14.27	< 0.001	0.23
SHR	6	282	4.25	< 0.001	0.08
Height × Sex	8	376	1.04	0.402	0.02
SHR × Sex	6	282	0.69	0.657	0.01
Height × SHR	48	2256	1.10	0.296	0.02
Height × SHR × Sex	48	2256	0.68	0.950	0.01

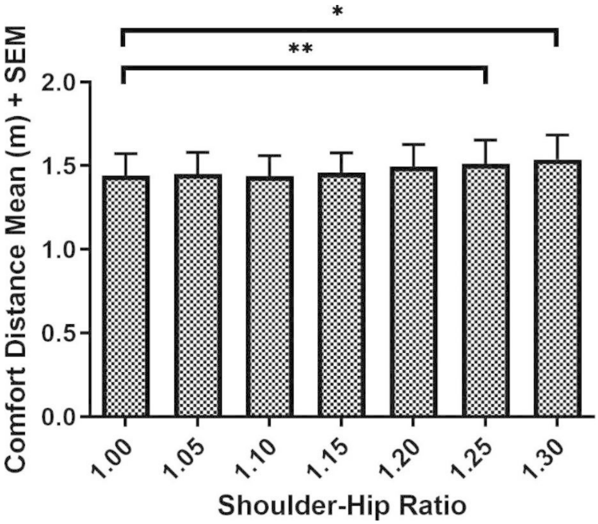

Fig. 3 Mean (+SEM) for stimuli varying in SHR. *$p<.05$, **$p<.01$

Post-hoc comparisons for height showed that participants preferred larger distances from the male stimulus with a 190 cm height ($M=1.72$, $SEM=0.17$, 95% CI [1.37, 2.06]) compared to 180 cm ($M=1.58$, $SEM=0.16$, 95% CI [1.25, 1.90], $p<.001$), 175 cm ($M=1.50$, $SEM=0.13$, 95% CI [1.23, 1.76], $p=.006$), 170 cm ($M=1.43$, $SEM=0.12$, 95% CI [1.18, 1.68], $p=.001$), 165 cm ($M=1.39$, $SEM=0.12$, 95% CI [1.15, 1.63], $p=.001$), 160 cm ($M=1.38$, $SEM=0.12$, 95% CI [1.14, 1.62], $p<.001$), 155 cm ($M=1.33$, $SEM=0.10$, 95% CI [1.11, 1.54], $p=.004$), and 150 cm ($M=1.31$, $SEM=0.10$, 95% CI [1.11, 1.50], $p=.004$; Fig. 4). Moreover, participants preferred larger distances from the stimulus with a 185 cm height ($M=1.64$, $SEM=0.16$, 95% CI [1.31, 1.97]) compared to 180 cm ($p=.025$), 170 cm ($p=.022$), 165 cm ($p=.004$), 160 cm ($p<.004$), 155 cm ($p=.023$), and 150 cm ($p=.021$). The comfort distance between a 180 cm height stimulus was significantly different from heights of 165 cm ($p=.049$), and 160 cm ($p=.035$). Also, participants preferred larger distances for a 175 cm height compared to heights of 165 cm ($p=.002$), 160 cm ($p=.004$), 155 cm ($p=.023$), and 150 cm ($p=.019$).

To further explore the association of Height, SHR, and Sex on comfort distance, Height and SHR were treated as continuous variables, and Sex as categorical, producing 3087 data points (9 Height × 7 SHR × 49 participants). A generalized addi-

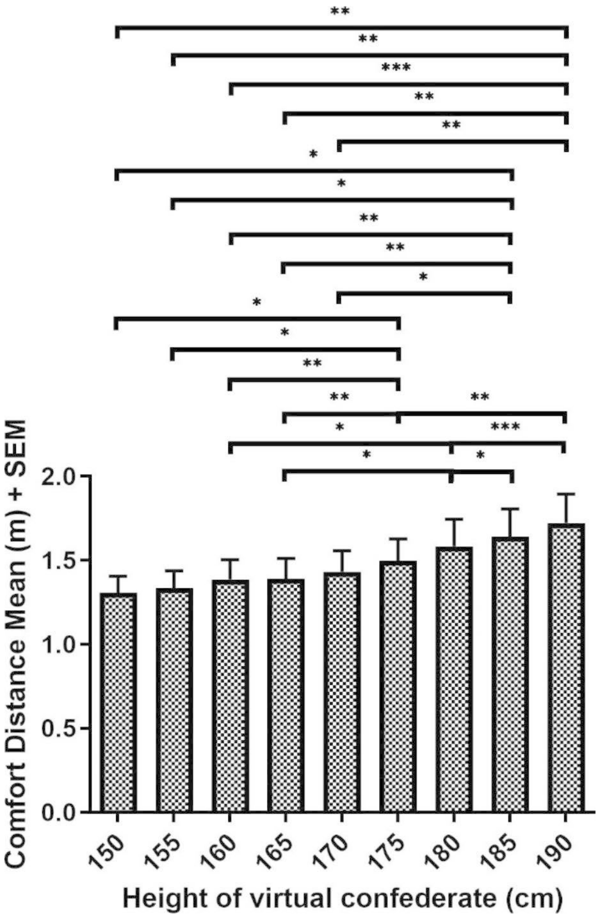

Fig. 4 Mean (+SEM) for stimuli varying in height. *$p<.05$, **$p<.01$

tive model (GAM) was conducted to investigate the non-linear relationship between Comfort Distance scores and the combination of Height and SHR (smooth term), and Sex, using a spline smoothing function. Results revealed a significant non-linear association between Comfort and Height and SHR ($F(2.646, 3084)=28.86, p<.001$). The effect of Sex on Comfort Distance scores was not significant, with both female ($\beta=0.05$, $SE=0.17$, $t=0.30$, $p=.759$) and male ($\beta=0.01$, $SE=0.23$, $t=0.06$, $p=.947$) participants showing similar levels of comfort. Overall, the model suggests that while the combination of Height and SHR has a significant effect on comfort distance, sex (male vs. female) does not have a significant effect. Figure 5 shows a three-dimensional scatterplot and regression plane for Height and SHR predicting comfort distance.

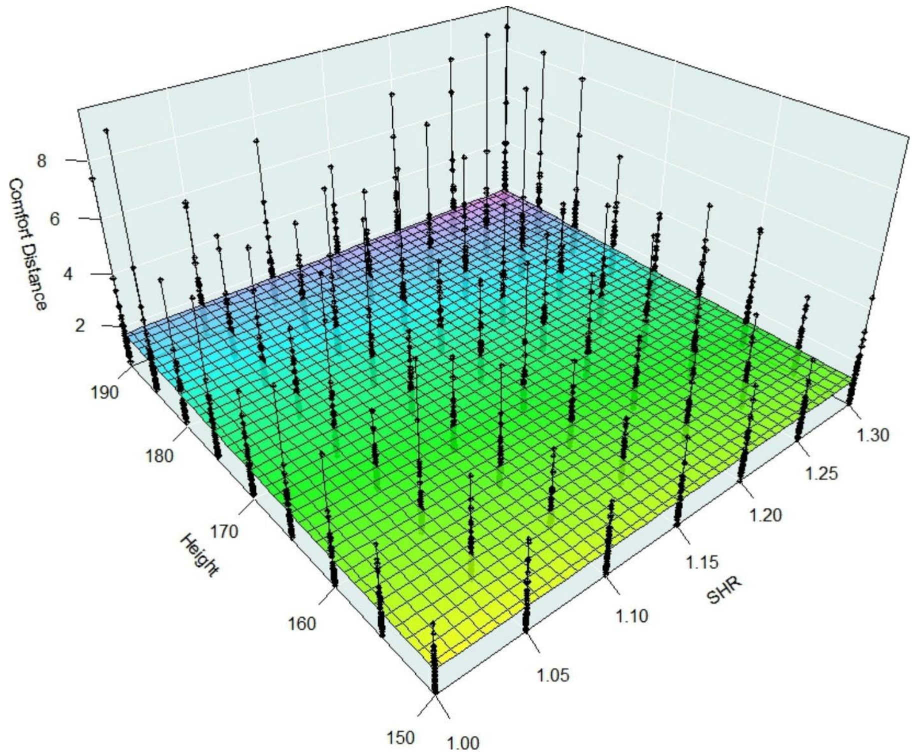

Fig. 5 Three-dimensional scatterplot and regression plane for height and SHR predicting comfort distance. As the color moves from yellow to violate the comfort distances increase

Discussion

The current study investigated the interacting effects of male height and SHR on comfort distance in a virtual reality experiment. Results showed that both men and women preferred larger distances from taller avatars, and the preferred distance increased steadily with the height of the male avatars. In contrast, and effect of SHR on comfort distance only emerged between the extreme ends of the ratios (i.e., avatars with extreme low SHR compared to those with very large SHRs). Furthermore, the height and SHR interaction did not modulate comfort distance. In other words, while our results show a conspicuous influence of male height on comfort distance, SHR generally does not affect interpersonal distance for social interactions. This dovetails with a recent VR study that separately tested the influence of men's height and SHR on comfort distance (Pazhoohi et al., 2019b). That study found an effect for height, but not for SHR. While the present study employed a broader range of height and SHR than those of Pazhoohi et al. (2019b), and combined the manipulation of SHR with height, the present results replicate the previous investigation.

Although past research has emphasized the importance of men's upper body size (i.e., SHR) on attractiveness (Dixson et al., 2010; Frederick & Haselton, 2007; Hughes & Gallup, 2003; Hughes et al., 2004; Pazhoohi et al., 2019a, b, 2022), the results of the current study and those of Pazhoohi et al. (2019b) indicates that it tends to have no significant effect on interpersonal interactions and comfort distance; thus, suggesting a dissociation between attractiveness perception of upper body size and the proxemics associated with it. This dissociation has clear implications for research on body size perception in virtual reality as it relates to social interactions and comfort distance. Specifically, where upper body size is manipulated such that height is confounded with SHR (e.g., Buck et al., 2022; Caplan & Goldman, 1981; D'Angelo et al., 2019; Ruggiero et al., 2019; Sakata et al., 2017), our data suggest that the observed effects will be carried by height and not SHR.

Our results are consistent with those of Pazhoohi and colleagues (2019b) on the importance of men's height in comfort distance, indicating the significance of tallness in men's formidability, fighting ability and resource holding power which can signal social status and dominance (Ellis, 1994; Parker, 1974; Pazhoohi et al., 2022; Sell et al., 2012; Stulp et al., 2015). This signifies the adaptive role of men's height in human evolutionary history (Stulp & Barrett, 2016).

In summary, the current research, when combined with previous work, indicates that both men and women prefer larger comfort distances from taller men, and the effect of SHR has a nominal effect. The implications for human body size research in virtual reality with an emphasis on the role of height compared to SHR are highlighted.

Author Contributions Conceptualization, F.P. and A.K.; data collection, S.B.H. formal analysis, F.P.; writing—original draft preparation, F.P.; writing—review and editing, F.P., S.B.H. and A.K. All authors have read and agreed to the published version of the manuscript.

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Availability of Data and Material Authors will share upon request.

Declarations

Conflict of interest The authors declare no conflict of interest.

Ethical Approval The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Behavioural Research Ethics Committee of the University of British Columbia.

Informed Consent Statement Informed consent was obtained from all subjects involved in the study.

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