Does perceived physical fitness affect perceived emotional state?

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Introduction

There is general belief that physical activity promotes mental well-being. There exists a myriad of research into the relationship between physical and mental health. A survey study conducted by (Hamer, Stamatakis and Steptoe, 2009) observed that 20 minutes of physical activity in a week is beneficial to mental health. A critical review from (Stroehle, 2009) on the present literature in regards with the effects of therapeutic exercises on patients suffering with mental health issues and exploration of association between physical activity and prevalence of depression and anxiety disorders concluded that changes to physical activity has a positive impact on mentally healthy subjects, but found that there is lack of systematic studies which explores the benefits of physical activity on patients with depression and anxiety.

However, to study and understand the emotional state of a person, researchers often must rely on various sensor and physiological markers to evaluate the emotional responses of the subject. To receive an emotional response, the subjects are often exposed to an array of audio-visual stimuli such as videos and images, which are not very immersive for the subjects. The VR Eyes: Emotions Dataset (VREED) from (Tabbaa *et al.,* 2021) provided the subject with a 360 virtual reality experience to achieve a deeply immersive virtual environment and collected a self-reported questionnaire and various sensor data from healthy participants.

This work thus aims to explore the relationship between a person's perception of their emotional state and their perceived physical health. For this the self-reported questionnaire from the VREED dataset is utilised and thus a link between the participants mental and physical state is explored.

Research Question

From the literature, it can be observed that there exists a relationship between physical health and mental health, and to an extent the emotional state. Thus, the research question and hypothesis can be formulated as follows: -

Research question: Does perceived physical fitness affect perceived emotional state?

H0: Perceived physical fitness does not affect perceived emotional state.

HA: Perceived physical fitness does affect perceived emotional state.

Data

The data for the VREED (Virtual Reality Emotion Recognition Dataset) study consists of pre-experiment, post-experiment, eye tracking, and biometric records of 34 participants. The experiment induces emotional responses in the participants by showing immersive Youtube videos in VR. The videos shown to participants are selected by focus group of 6 researcher in Human-Computer Interaction and psychology. Where the researchers met to discuss and experience 126 virtual environments to identify suitable environments for the pilot study.

The pilot trial consisted of 12 volunteers which engaged and rated with the 21 selected virtual environments using the SAM (arousal, valence) and VAS (joy, anger, calmness, sadness, disgust, relaxation, happiness, fear, anxiousness, and dizziness). After which participants for the study provided their demographic information and answered questionnaire regarding their health inclusion and provided baseline arousal, valence and VAS rating. This information is stored in the Pre-Exposure part of the dataset. After which the participants are exposed to emotional stimuli using the VR environments and their SAM and VAS ratings are recorded again in the post-exposure part of the dataset. During this study the physiological signals of the participants are also recorded.

The pre-exposure part of the dataset provides the answers from the participants to various questions regarding their health and their perceived emotional states. These questions can broadly be classified in 4 parts, i.e., demographic information, health, questions regarding their perception if themselves and lastly questions regarding their emotional state (the extent to which they are feeling a specific emotion). The variables VR_Ever, Vr_Dizzy, Mo_Sick, Health_Qn (n= 01 to 19) stores the health information of the participant and ITQn (n=01 to 18) stores the information about participant's perception about themselves.

The variable ITQ7, in particular stores the answers to the question "How physically fit do you feel today?" which are on a Likert where 0=Not Fit, 3=Moderately Fit, 6=Extremely Fit. Table 1 contains the details regarding the variables storing the perceived emotional state of the participants.

Table1. Description of the variables storing the perceived emotional state (Tabbaa *et al.,* 2021).

The aim of this study is to investigate relationship between perceived physical fitness and perceived emotional state from the 34 participants. This is investigated by checking for an association between the predictor of physical fitness, and the outcome of emotional state in the "PRE-EXPOSURE" data.

PRE_Joy	To what extent do you feel joyful right now?	Continuous numerical variable (0-100) where 0=Not joyful at all, 100 = As joyful as I can be
PRE_Anger	To what extent do you feel angry right now?	Continuous numerical variable (0-100) where 0=Not angry at all, 100 = As angry as I can be
PRE_Calmness	To what extent do you feel calm right now?	Continuous numerical variable (0-100) where 0=Not calm at all, 100 = As calm as I can be
PRE_Sadness	To what extent do you feel sad right now?	Continuous numerical variable (0-100) where 0=Not sad at all, 100 = As sad as I can be
PRE_Disgust	To what extent do you feel disgusted right now?	Continuous numerical variable (0-100) where 0=Not disgusted at all, 100 = As disgusted as I can be
PRE_Relaxation	To what extent do you feel relaxed right now?	Continuous numerical variable (0-100) where 0=Not relaxed at all, 100 = As relaxed as I can be
PRE_Happiness	To what extent do you feel happy right now?	Continuous numerical variable (0-100) where 0=Not happy at all, 100 = As happy as I can be
PRE_Fear	To what extent do you feel fearful right now?	Continuous numerical variable (0-100) where 0=Not fearful at all, 100 = As fearful as I can be
PRE_Anxiousness	To what extent do you feel anxious right now?	Continuous numerical variable (0-100) where 0=Not anxious at all, 100 = As anxious as I can be

Thus, the relevant variables in this study from the VREED dataset are – "Physically_fit","PRE_Joy", "PRE_Anger", "PRE_Calmness", "PRE_Sadness", "PRE_Disgust", "PRE_Relaxation", "PRE_Happiness", "PRE_Fear", and "PRE_Anxiousness". Table 2 statistically explores the aforementioned variables.

Table2. Exploratory statistics for the relevant variables.

	Mean	**Median**	**Variance**	**Std. Deviation**	**Minimum**	**Maximum**	**Range**
Physically_Fit	4.41	5	1.765	1.328	1	6	5
PRE_Joy	40.24	40.5	576.064	24.001	0	83	83
PRE_Anger	5.56	0	226.981	15.066	0	0	76
PRE_Calmness	75.12	80	442.41	21.034	21	100	79
PRE_Sadness	7.47	1	170.439	13.055	0	56	56
PRE_Disgust	0.85	0	5.766	2.401	0	14	14
PRE_Relaxation	67.41	67.5	499.462	22.349	0	100	100
PRE_Happiness	49.74	52	603.898	24.574	0	100	100
PRE_Fear	2.29	1	13.971	3.738	0	14	14
PRE_Anxiousness	10.5	4	228.015	15.1	0	75	75

Right away it is evident that there are highly varied responses from the participants reporting their happiness, relaxation, and anxiousness. However, overall higher mean of Pre_Calmness variable suggests that most participants were calm during the study. One key thing to notice, that the study is limited to only participants' perception of their own physical fitness and emotional state and could not define physical health or prove how physically healthy the participants are.

Analytical Approach

To investigate the relationship between physical fitness and emotional state, the analysis examines the independent variable – ITQ7: "How physically fit do you feel today?" (Physically Fit) and dependent variables – "PRE_Joy", "PRE_Anger", "PRE_Calmness", "PRE_Sadness", "PRE_Disgust", "PRE_Relaxation", "PRE_Happiness", "PRE_Fear", and "PRE_Anxiousness". As per the research question, the strength of relationship between ITQ7: "How physically fit do you feel today?" and other emotional variables is being investigated which would help establish potential connection between the variables in question. Therefore, correlation analysis is the appropriate statistical analysis to test the hypothesis.

Furthermore, as the relationship between the variables is being investigated using the correlation analysis, and the order of the data points is not essential for our investigation, scatter plots can be utilised to visually inspect the relationship between the variable pairs. This would also clarify and help observe the trends in the data and help verify if there exists a linear or monotonic relationship between the data.

Tests Selected

Two of the most common statistical tests used in Correlation analysis are the Pearson's correlation and the spearman's rank correlation. One of the requirements of Pearson's correlation is that each variable in the investigation be continuous. Even though the dependent variables in this study are continuous numerical in nature, the independent variable ITQ7 is ordinal in nature. Additionally, Pearson's correlation assumes the data to be approximately normally distributed, but as the ITQ7 is on the Likert scale, thus it cannot be normally distributed which fails the assumption of Pearson's correlation. Furthermore, on visually inspecting the scatterplots between the variables we can observe that the relationship between the variables is non-linear in nature. Scatter plots between the investigated variables are available in appendix A. Therefore, the Pearson's correlation test, would not be appropriate in this case.

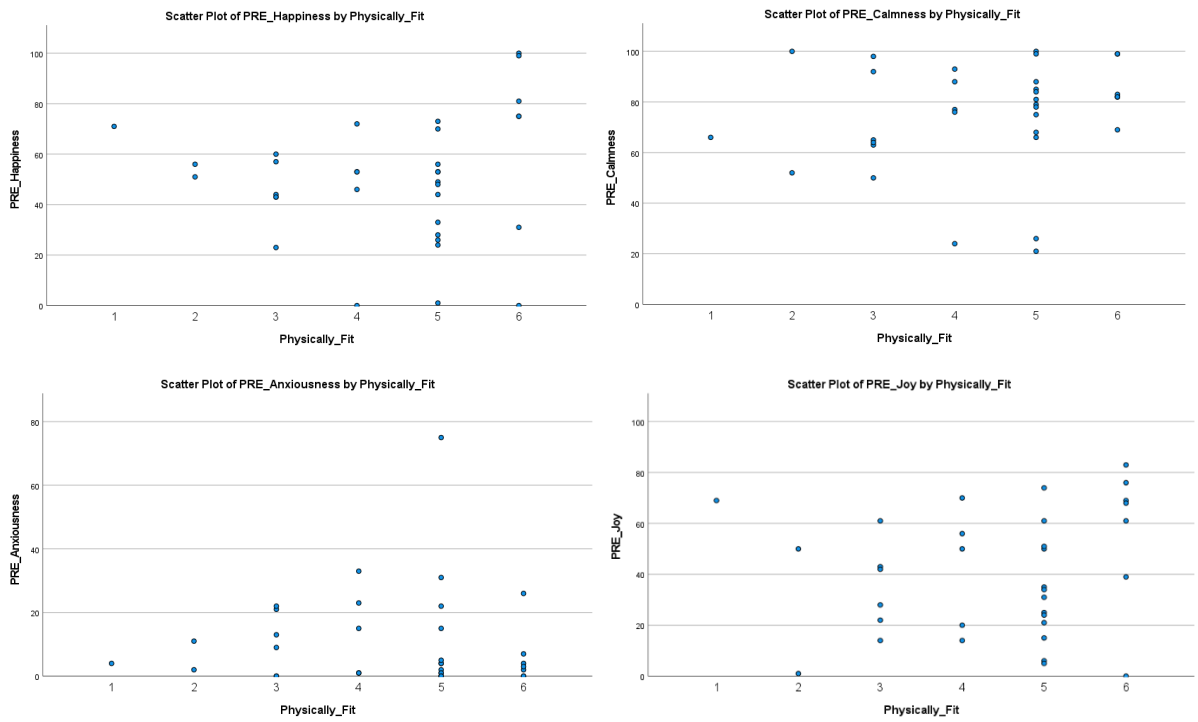


Fig1. Scatter plots of emotional variables by Physically_Fit

On the other hand, Spearman's correlation is an appropriate test for correlation analysis when the assumptions for Pearson's correlation are not satisfied. Additionally, as the nature of relationship between the variables seem non-linear, the strength and the direction of the monotonic relationship between the variables can be determined with the Spearman's correlation. Thus, the Spearman's rank correlation coefficient (Spearman's correlation) would be used to investigate the strength of the correlation.

Test Results

Keeping the research question in mind and based on the visual inspection of the scatterplot , the nature of the types of dependent and independent variables, and the type of distribution of the data, Spearman's correlation was conducted as the method of correlation analysis on the relevant variables. Table 3 shows the statistical information about the outcome of Spearman's correlation test.

Table3. Results of the Spearman's correlation test.

SPEARMAN'S CORRELATION

		PRE_ Joy	PRE_ Anger	PRE_ Calmness	PRE_ Sadness	PRE_ Disgust	PRE_ Relaxation	PRE_ Happiness	PRE_ Fear	PRE_ Anxiousness

PHYSICALLY_FIT	Correlation Coefficient	0.197	-0.04	0.256	-0.152	-0.148	0.323	0.162	0.068	-0.139
	Sig. (2-tailed)	0.265	0.824	0.144	0.391	0.403	0.063	0.360	0.703	0.435
	N	34	34	34	34	34	34	34	34	34

**. CORRELATION IS SIGNIFICANT AT THE 0.01 LEVEL (2-TAILED).

*. CORRELATION IS SIGNIFICANT AT THE 0.05 LEVEL (2-TAILED).

The result of the Spearman's correlation shows that there is a weak positive (r_s>0.20) correlation between "Physically_Fit" with "PRE_Relaxation" and "PRE_Calmness". However, there exists no correlation (-0.20<r_s<=0.20) for other variables. Additionally, as all the 2 tailed significance values are greater than 0.05 (p>0.05) these results are not statistically significant.

Although ,looking further into the correlations between the variables in the Table 4, some interesting relationships can be found. The variables "PRE_Happiness" and "PRE_Joy" are highly positively correlated with each other (r_s > 0.70). Similarly, the variables "PRE_Sadness", "PRE_Disgust" , "PRE_Fear" are all moderately positively correlated with the variable "PRE_Anger" (r_s > 0.40). Lastly, "PRE_Relaxation" and "PRE_Calmness" are also found to by moderately high positively correlated with each other(r_s > 0.60).

Table 4. Spearman's correlation between all the variables.

Correlations

			Physically_Fit	PRE_Joy	PRE_Anger	PRE_Calmness	PRE_Sadness	PRE_Disgust	PRE_Relaxation	PRE_Happiness	PRE_Fear	PRE_Anxiousness
Spearman's rho	Physically_Fit	Correlation Coefficient	1.000	.197	-.040	.256	-.152	-.148	.323	.162	.068	-.139
		Sig. (2-tailed)	.	.265	.824	.144	.391	.403	.063	.360	.703	.435
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Joy	Correlation Coefficient	.197	1.000	-.081	.227	.163	-.086	.306	.711**	.025	.210
		Sig. (2-tailed)	.265	.	.650	.197	.358	.630	.078	<.001	.887	.233
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Anger	Correlation Coefficient	-.040	-.081	1.000	.178	.422*	.641**	.262	-.130	.528**	-.120
		Sig. (2-tailed)	.824	.650	.	.314	.013	<.001	.135	.463	.001	.498
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Calmness	Correlation Coefficient	.256	.227	.178	1.000	.070	.120	.608**	.308	.111	-.158
		Sig. (2-tailed)	.144	.197	.314	.	.693	.500	<.001	.077	.532	.371
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Sadness	Correlation Coefficient	-.152	.163	.422*	.070	1.000	.394*	.030	.040	.200	.178
		Sig. (2-tailed)	.391	.358	.013	.693	.	.021	.868	.823	.257	.314
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Disgust	Correlation Coefficient	-.148	-.086	.641**	.120	.394*	1.000	.197	-.086	.488**	-.149
		Sig. (2-tailed)	.403	.630	<.001	.500	.021	.	.265	.630	.003	.401
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Relaxation	Correlation Coefficient	.323	.306	.262	.608**	.030	.197	1.000	.305	-.043	-.292
		Sig. (2-tailed)	.063	.078	.135	<.001	.868	.265	.	.079	.811	.094
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Happiness	Correlation Coefficient	.162	.711**	-.130	.308	.040	-.086	.305	1.000	-.044	.219
		Sig. (2-tailed)	.360	<.001	.463	.077	.823	.630	.079	.	.806	.213
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Fear	Correlation Coefficient	.068	.025	.528**	.111	.200	.488**	-.043	-.044	1.000	.067
		Sig. (2-tailed)	.703	.887	.001	.532	.257	.003	.811	.806	.	.705
		N	34	34	34	34	34	34	34	34	34	34
	PRE_Anxiousness	Correlation Coefficient	-.139	.210	-.120	-.158	.178	-.149	-.292	.219	.067	1.000
		Sig. (2-tailed)	.435	.233	.498	.371	.314	.401	.094	.213	.705	.
		N	34	34	34	34	34	34	34	34	34	34

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

In these cases, however, unlike the relationship between "Physically_Fit" and other variables, the results are statistically significant (p<0.05) with "PRE_Disgust"-"PRE_Anger", "PRE_Relaxation"-

“PRE_Calmness” and “PRE_Happiness”-“PRE_Joy” all having their correlation significant at the level less than 0.001 ($p<0.001$).

Interpretation

Based on the results from the conducted correlation study utilising the Spearman’s Correlation test on the independent variable– ITQ7: “How physically fit do you feel today?” (Physically Fit) and dependent variables – “PRE_Joy”, “PRE_Anger”, “PRE_Calmness”, “PRE_Sadness”, “PRE_Disgust”, “PRE_Relaxation”, “PRE_Happiness”, “PRE_Fear”, and “PRE_Anxiousness”. There was a weak positive correlation found between the “Physically_Fit” with “PRE_Relaxation” and “PRE_Calmness”. However, these results were found to be not statistically significant. With this it can be concluded that in the VREED dataset participant’s perceived physical fitness did not affect the participant’s perceived emotional state. Thus, we can accept the null hypothesis (H0) that ***Perceived physical fitness does not affect perceived emotional state.***

References

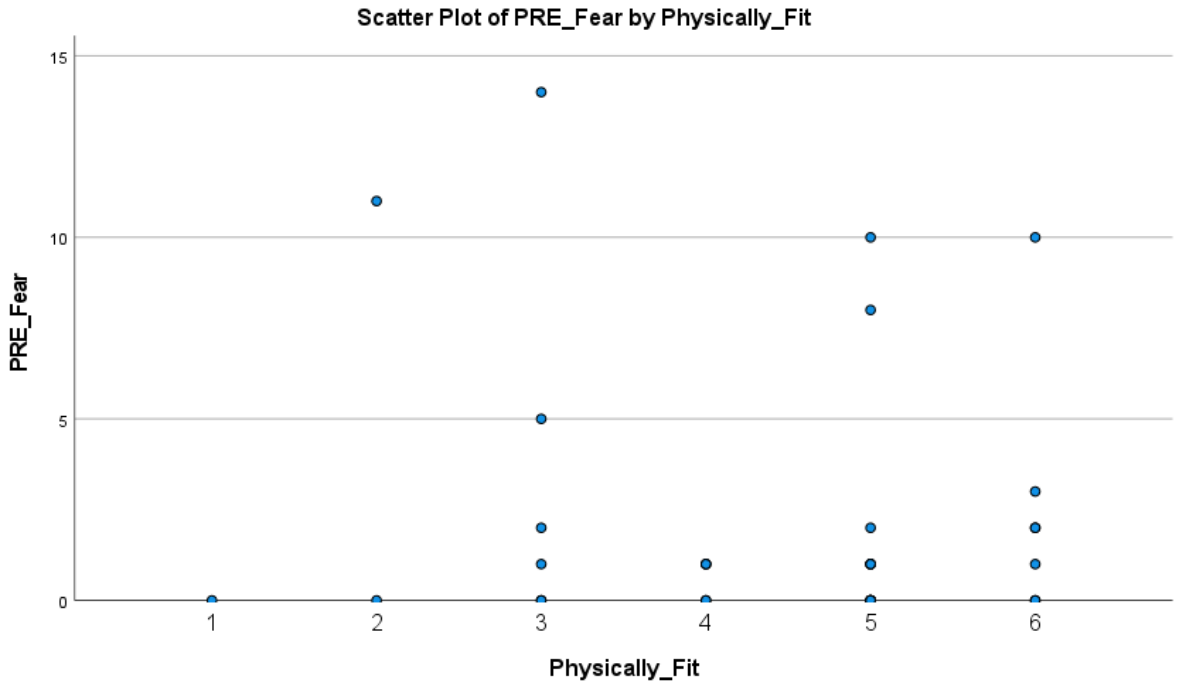
Hamer, M., Stamatakis, E. and Steptoe, A. (2009) 'Dose-response relationship between physical activity and mental health: the Scottish Health Survey', *British journal of sports medicine; Br J Sports Med,* 43(14), pp. 1111-1114. doi: 10.1136/bjsm.2008.046243.

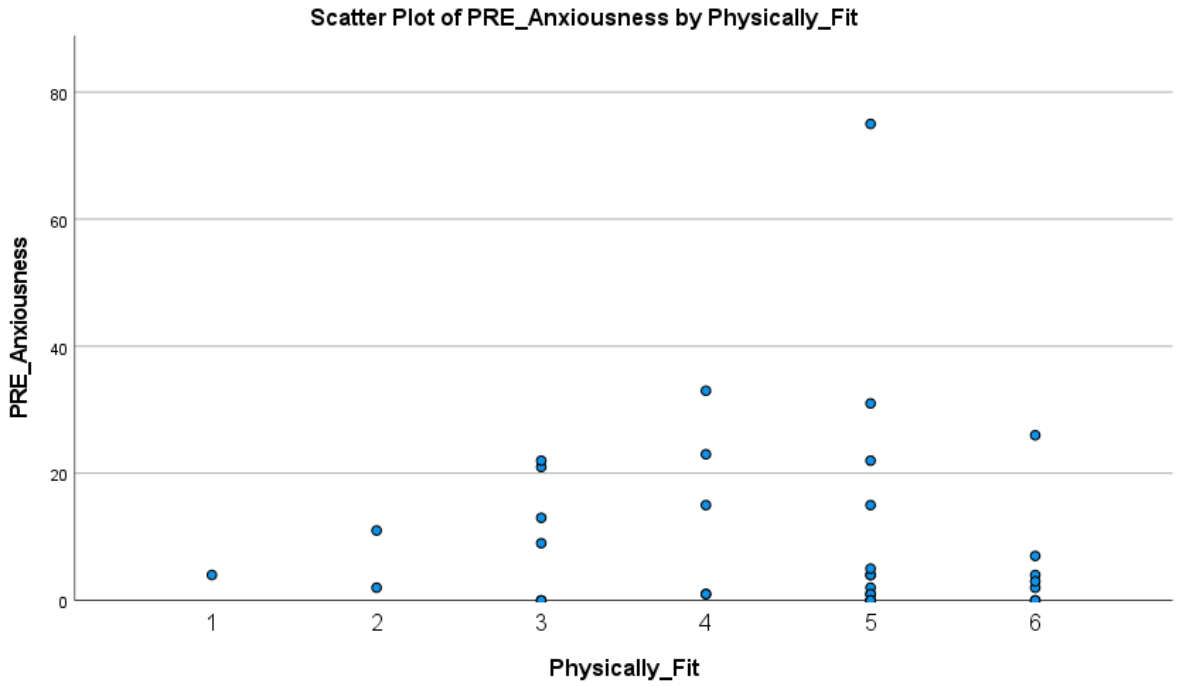
Stroehle, A. (2009) 'Physical activity, exercise, depression and anxiety disorders', *Journal of neural transmission,* 116(6), pp. 777-784. doi: 10.1007/s00702-008-0092-x.

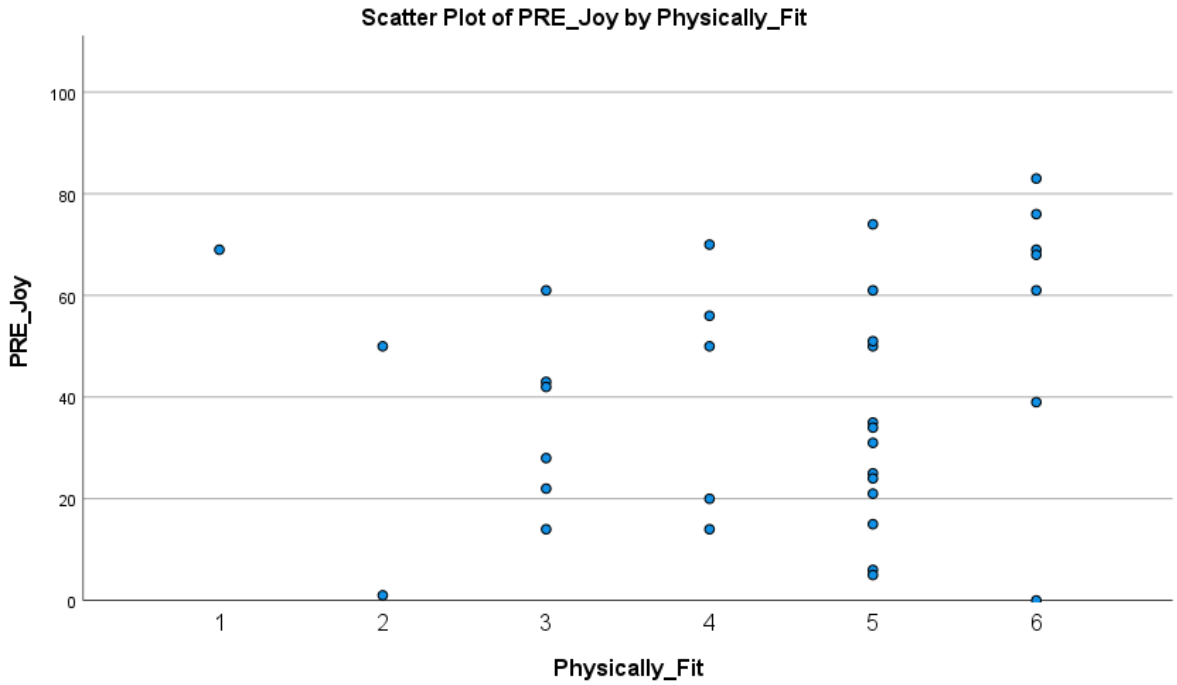
Tabbaa, L., Searle, R., Bafti, S.M., Hossain, M.M., Intarasisrisawat, J., Glancy, M. and Ang, C.S. (2021) 'VREED: Virtual Reality Emotion Recognition Dataset Using Eye Tracking & Physiological Measures', *Proceedings of ACM on interactive, mobile, wearable and ubiquitous technologies,* 5(4), pp. 1-20. doi: 10.1145/3495002.

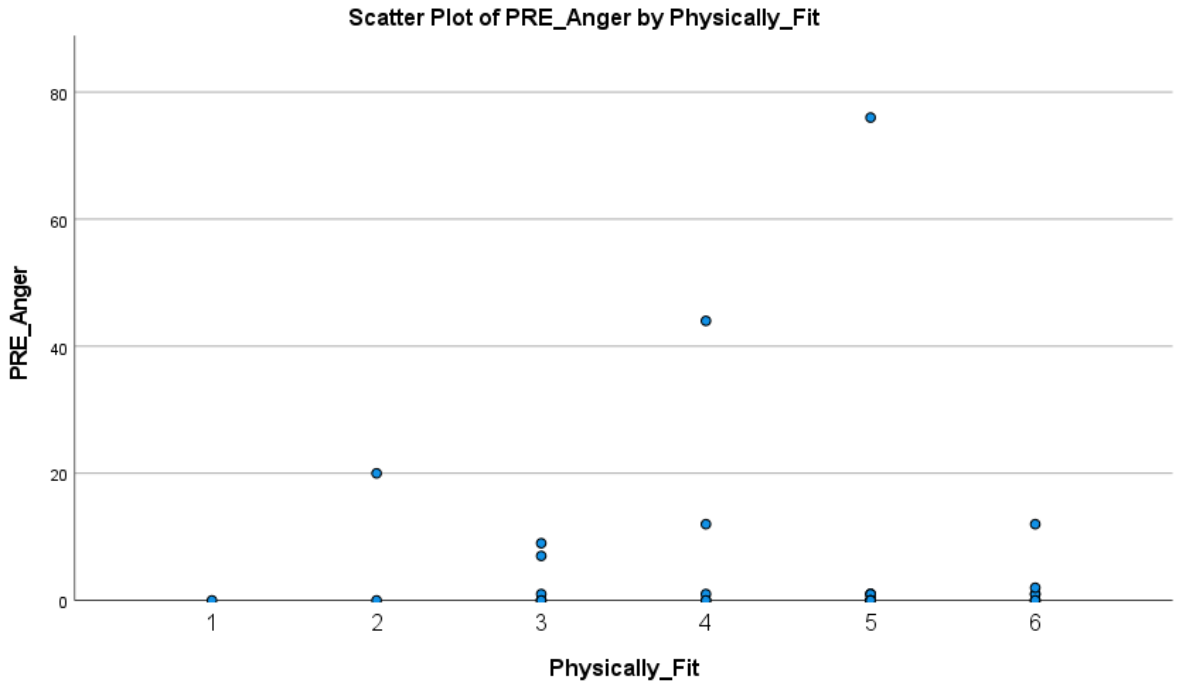
Appendix – A

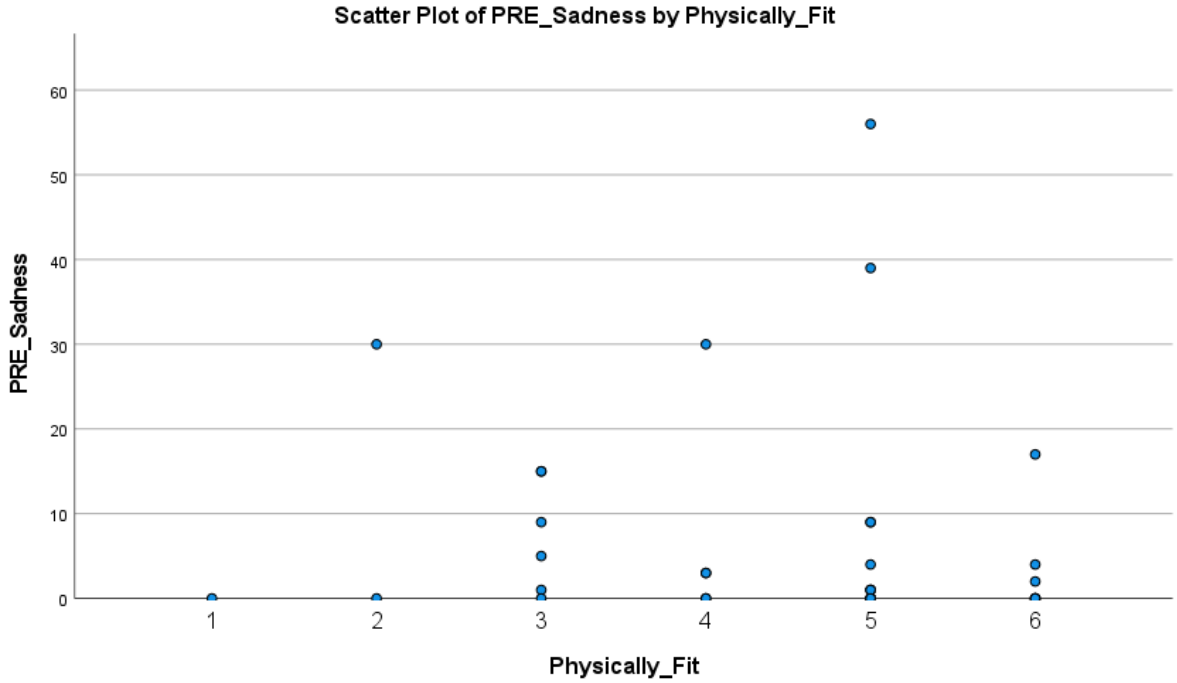
Scatter plots between Physically_Fit and Other emotional variables.

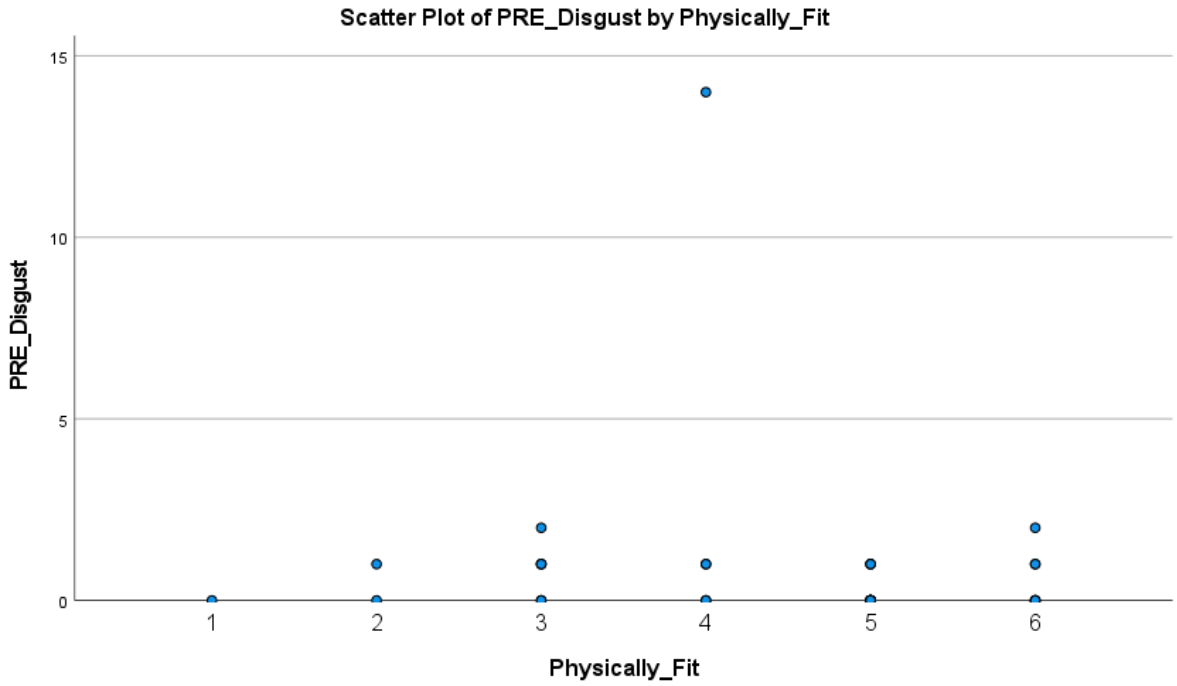

Scatter Plot of PRE_Fear by Physically_Fit
PRE_Fear
15
10
5
0
1
2
3
4
5
6
Physically_Fit

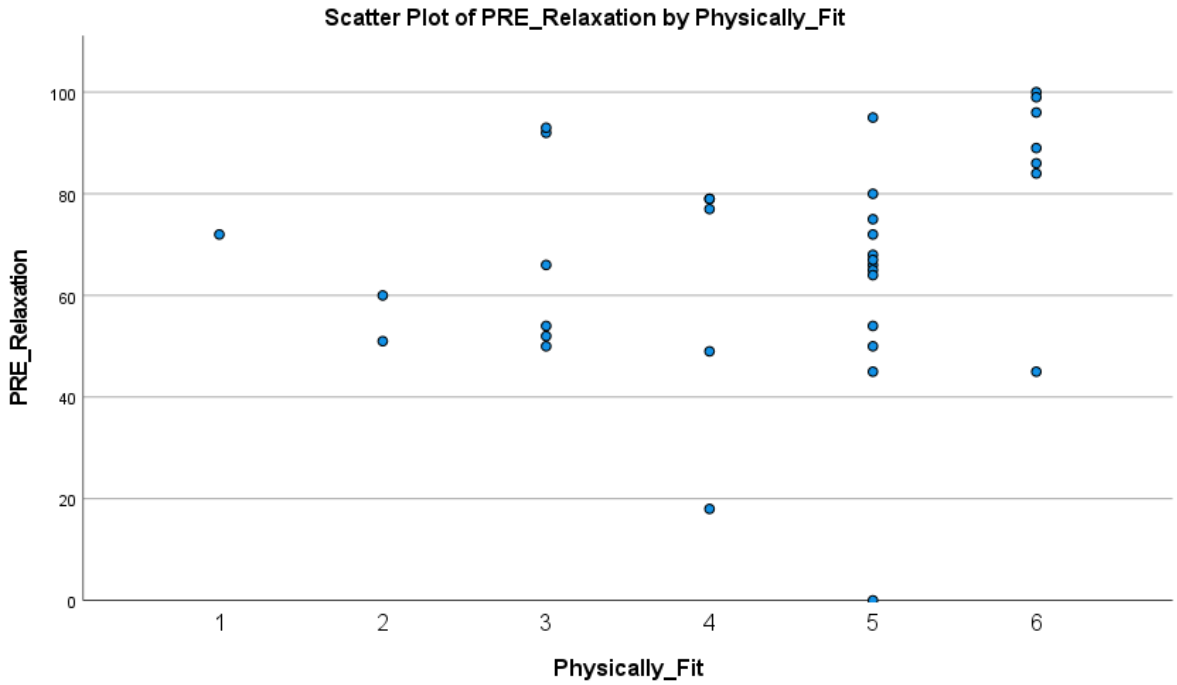

Scatter Plot of PRE_Anxiousness by Physically_Fit
PRE_Anxiousness
80
60
40
20
0
1
2
3
4
5
6
Physically_Fit


Scatter Plot of PRE_Joy by Physically_Fit
PRE_Joy
100
80
60
40
20
0
1
2
3
4
5
6
Physically_Fit


Scatter Plot of PRE_Anger by Physically_Fit
PRE_Anger
80
60
40
20
0
1
2
3
4
5
6
Physically_Fit


Scatter Plot of PRE_Sadness by Physically_Fit
PRE_Sadness
60
50
40
30
20
10
0
1
2
3
4
5
6
Physically_Fit


Scatter Plot of PRE_Disgust by Physically_Fit
PRE_Disgust
15
10
5
0
1
2
3
4
5
6
Physically_Fit


Scatter Plot of PRE_Relaxation by Physically_Fit
PRE_Relaxation
100
80
60
40
20
0
1
2
3
4
5
6
Physically_Fit