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Can Biometric Signals Capture Mental Tension During Golf? A Pilot Study Using ECG and Wearable Pulse Sensors

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Background

Golf is a sport that demands delicate technique and intense mental focus, and a player's psychological state during play can significantly affect performance. The detrimental impact of psychological pressure on athletic performance is a common challenge faced by athletes across all sports. (Tanaka, M. (Year). An Experimental Study on Golf Putting under Psychological Pressure: Symptoms and Coping Strategies, p.1)*

During competition, athletes are particularly prone to acute stress, such as pre-shot tension or post-error frustration.

Due to psychological pressure, players often miss critical putts, resulting in outcomes that fall short of expectations. (Tanaka, M. (Year). An Experimental Study on Golf Putting under Psychological Pressure: Symptoms and Coping Strategies, p.2)

Purpose

This study aims to clarify how emotional states and stress fluctuate during golf play, and how these changes influence heart rate variability (HRV) indices and performance. In this pilot study, we aimed to investigate whether biometric signals can capture mental tension during golf play. Four healthy male participants were monitored while playing a full round of golf. We used a Holter ECG and a wearable pulse wave sensor to collect physiological data, including three-axis acceleration, R-R intervals (RRI), and heart rate variability (HRV) indices such as SDNN, LF, HF, and LF/HF ratio.

Measurement method

• measurement devices

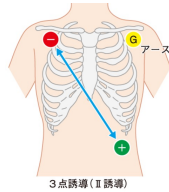
• Holter ECG



• wearable pulse wave sensor



- Holter ECG...Measurements were conducted using the three-lead configuration shown in the right figure.
- wearable pulse wave sensor ... Measurements were taken with the device attached to the left arm.



The device was worn continuously from before to after the golf round, and heart rate variability (HRV) indices were calculated from the recorded data.

• Measurement indices

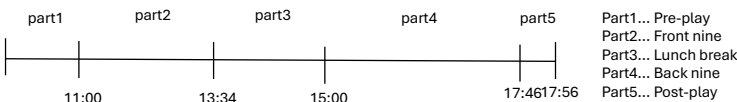
Holter ECG	RRI, Three-axis acceleration
wearable pulse wave sensor	kin temperature, etc

• Three-axis acceleration

Acceleration was calculated using the following equation.

$$\text{Composite acceleration} = \sqrt{x^2 + y^2 + z^2}$$

• Measurement duration



• HRV Indices: Frequency and Time Domains

VLF	Influenced by parasympathetic activity
LF	Influenced by both sympathetic and parasympathetic activity
HF	Primarily sympathetic, with partial parasympathetic influence
LF/HF	Influence of sympathetic function

Stress tends to decrease HF and increase LF, reflecting heightened autonomic nervous system activity.

Stress is defined as a state in which the autonomic nervous system is dominated by sympathetic activity (arousal), whereas relaxation corresponds to parasympathetic dominance." (Mori, Matsumoto, & Jiangwei, 2004, p.114)

In this study, stress was assessed using the LF/HF ratio

MEAN	Indicates basic heart rhythm; higher values reflect lower heart rate and rest
SDNN	Reflects autonomic activity; higher values indicate greater cardiac flexibility
RMSSD	Reflects parasympathetic activity; sensitive to short-term HRV
NN50	Indicates parasympathetic activity; higher values reflect a relaxed state
PNN50	Parasympathetic index
TP	Index of stress resilience and intrinsic vitality

• Survey

- A brief questionnaire was administered after each hole to examine the relationship between subjective ratings and performance scores.

ID.004		holeNo:1			
Question	Not at all	Slightly	Moderately	Very	Extremely
	0	1	2	3	4
* Did you enjoy playing this hole?					
* Did you feel irritated after playing this hole?					
* Did you feel surprised after playing this hole?					
* Did you feel relaxed while playing this hole?					
* Did you find this hole boring?					
* Did you feel physically tired after playing this hole?					
* Did you feel nervous while putting?					
* Did you like this hole?					
* Please describe any other thoughts or feelings you had.					

Measurement results

player2	MEAN	SDNN	RMSSD	NN50	PNN50	TP	VLF	LF	HF	LF/HF
Part1	813.43	83.239	36.208	21	18.261	6114.709	2149.5	3207.623	1446.129	2.2181
Part2	823	92.456	33.556	40	12.945	8326.954	5184.974	2975.288	993.5541	2.9946
Part3	733.35	133.63	32.052	18	10.651	12232.47	7114.343	6284.183	780.734	8.0491
Part4	664.76	129.24	28.691	33	9.9099	15428.16	13589.68	2315.302	334.8717	6.914
Part5	623.83	56.005	18.415	0	0	990.3183	158.1683	366.0653	511.6949	6.7154

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player3	MEAN	SDNN	RMSSD	NN50	PNN50	TP	VLF	LF	HF	LF/HF
Part1	668.52	74.174	15.396	0	0	964.9865	208.1154	638.4712	237.433	2.6891
Part2	619.7	44.476	13.716	4	1.2945	2215.767	1322.307	1052.061	153.6645	6.8517
Part3	553.35	41.011	6.6349	0	0	109.1049	46.0128	61.0037	14.5955	4.1726
Part4	513.69	58.496	9.1767	0	0	1076.028	939.2811	178.2517	42.1902	4.225
Part5	622.6	19.884	12.87	0	0	161.4946	22.9672	54.1991	87.415	0.62

player1	STEP	CONV	PR	skintemp	UV	act	PPI
Part1	18.5333	0.333333	64.16279	27.70614	3	1138.845	841.0979
Part2	15.57419	0.374194	67.75484	29.42327	3.04758	1124.198	743.3959
Part3	18.89326	0.588235	60.59036	28.01999	0.97867	1050.702	867.1713
Part4	18.79042	0.3590281	67.25904	26.71712	0.99812	1109.279	776.0055
Part5	22.5	0.1	59.5	23.0809	2.2129	1082.648	903.7073

player2	STEP	CONV	PR	skintemp	UV	act	PPI
Part1	27.18815	0.48889	55	28.20544	0.558333	1070.73	
Part2	19.49032	0.4	29.29688	1.125403	1109.547		
Part3	14.48235	0.341176	28.0569	0.310294	1052.578		
Part4	23.59281	0.335329	81.65269	26.68199	0.35329	1100.17	627.088
Part5	11.4	0.4	73.8	23.993	0.0375	1057.78	715.333

Results from the wearable pulse wave sensor (blank fields indicate missing data and uncalculated values).

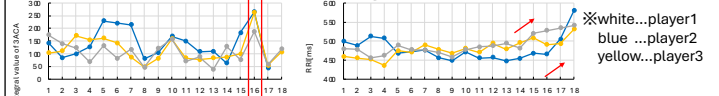
• From the Holter ECG

- SDNN, RMSSD, and PNN50 tended to be higher during non-playing periods, indicating increased parasympathetic activity.
- During play, VLF and LF tended to increase while HF decreased, resulting in a higher LF/HF ratio, which indicates a state of stress or heightened arousal.
- After play, the LF/HF ratio markedly decreased, indicating a relaxed physiological state.

• From the wearable pulse wave sensor

During play, RRI tended to decrease, indicating sympathetic dominance and elevated stress levels.

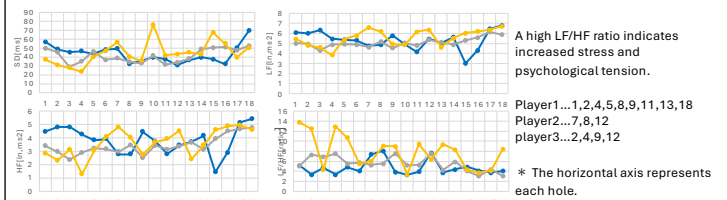
• Triaxial Acceleration and RRI by Hole



At hole 16, acceleration increased and all players recorded poorer scores.

RRI gradually increased in the latter half of the session.

• SD, LF, HF, LF/HF (Calculated based on RRI values for each hole.)

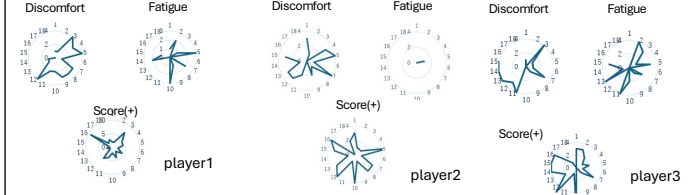


A high LF/HF ratio indicates increased stress and psychological tension.

Player1...1,2,4,5,8,9,11,13,18
Player2...7,8,12
Player3...2,4,9,12

* The horizontal axis represents each hole.

• Selected Survey Results



Results, Discussion, Conclusion

• Result 1: Relationship Between Subjective Ratings and Performance Score

- Holes with lower scores were associated with higher subjective discomfort ratings, indicating a link between performance and perceived stress.

The results indicated a correlation between poor scores and higher subjective stress ratings. This may be due to the fact that the questionnaire was administered after each hole, suggesting that players who performed poorly may have retrospectively perceived the experience as more unpleasant. However, there were also instances where high discomfort was reported despite relatively good scores. Therefore, administering the questionnaire after each shot, rather than after each hole, may allow for a more accurate assessment of the relationship between subjective stress and performance.

• Result 2: Relationship Between Performance Score and Biometric Indicators

- An increased number of strokes was observed on holes where physiological indicators reflected elevated stress.

Analysis showed that increased acceleration, as captured by physiological sensors, was associated with worse scores. This suggests that acceleration may serve as a predictive marker for performance outcomes.

The results of this study suggest that stress experienced during golf play is associated with performance. However, due to the small sample size—three participants for heart rate variability (HRV) data and four for subjective evaluations—further research with a larger cohort is needed to examine this relationship in greater depth.

References

- (1) ドリームニュース.世界最小・最軽量で、入浴対応 超小型防水ホルター心電計「Cardy 303 pico+」を新発売. 世界最小・最軽量で、入浴対応 超小型防水ホルター心電計「Cardy 303 pico+」を新発売(株式会社スズケンのプレスリリース)
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- (3) 右藤. root. モーター心電図の装着法. モーター心電図の装着法「右藤root」カンゴロー