

Development and Comparison of Heart Rate-Based Energy Expenditure Prediction Models During Taekwondo Poomsae



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Introduction

Background

- Taekwondo poomsae elicits physiological responses, including changes in heart rate (HR) and energy expenditure (EE).
- Quantifying EE during Taekwondo poomsae performance may provide valuable information for understanding the metabolic demands of exercise and evaluating training load in athletes.
- HR is widely used as a practical, non-invasive physiological indicator for estimating EE during various types of exercise.
- However, the predictive accuracy of HR-based EE estimation during Taekwondo poomsae, particularly when incorporating individual physical characteristics, has not been sufficiently investigated.

Purpose

- To develop EE prediction models using HR and physical characteristics during Taekwondo poomsae and to compare their explanatory power and predictive accuracy.

Methods

- A total of 14 male collegiate Taekwondo poomsae athletes participated (Table 1).
- The study included 8 poomsae from men's collegiate competitions: Taegeuk 7, Taegeuk 8, Koryo, Keumgang, Taebaek, Pyongwon, Sipjin, and Jitae.
- Each participant performed all eight poomsae in a randomized order (112 trials).
- HR, EE, and body composition were measured using Polar H10, COSMED K5, and InBody, respectively.
- Five linear regression models were developed (Table 2). Model fit was evaluated using R^2 , while predictive accuracy was assessed using MAE and RMSE through LOSO-CV.

Table 1. Physical Characteristics of Participants

Variable	Mean $\pm$ SD
Age (years)	19.4 $\pm$ 0.7
Height (cm)	173.5 $\pm$ 5.6
Weight (kg)	66.2 $\pm$ 6.5
BMI (kg/m ²)	22.0 $\pm$ 1.5
Fat-free Mass (kg)	56.9 $\pm$ 5.6
Fat Mass (kg)	9.3 $\pm$ 2.6

Table 2. Prediction Models

Model	Predictors
Model 1	Mean HR
Model 2	Mean HR + Weight
Model 3	Mean HR + Fat-free Mass
Model 4	Mean HR + Fat Mass
Model 5	Mean HR + BMI

Results

Table 3. Model fit and predictive accuracy for each prediction model

Model	Predictors	R ²	MAE (kcal/min)	RMSE (kcal/min)
Model 1	Mean HR	0.134	1.296	1.598
Model 2	Mean HR + Weight	0.368	1.171	1.441
Model 3	Mean HR + Fat-free Mass	0.403	1.131	1.390
Model 4	Mean HR + Fat Mass	0.143	1.429	1.751
Model 5	Mean HR + BMI	0.233	1.317	1.600

- Model 3 (HR + fat-free mass) showed the highest R^2 (0.403) and the lowest prediction errors (MAE = 1.131 kcal/min; RMSE = 1.390 kcal/min).
- Compared with Model 1 (HR alone), Model 3 reduced MAE by 12.7% and RMSE by 13.0%.

Discussion

- Incorporating physical characteristics into HR-based models increased explanatory power compared with using HR alone.
- Among the physical characteristics examined, fat-free mass showed the best model performance when combined with HR.
- Although the best-performing model showed modest explanatory power ($R^2 = 0.403$), the findings provide preliminary evidence for the potential of HR-based EE estimation during Taekwondo poomsae.
- The small sample size ($n = 14$) and inclusion of only male collegiate athletes may limit the generalizability of the findings.

Keywords: Taekwondo, Poomsae, Heart Rate, Energy Expenditure, Prediction Model

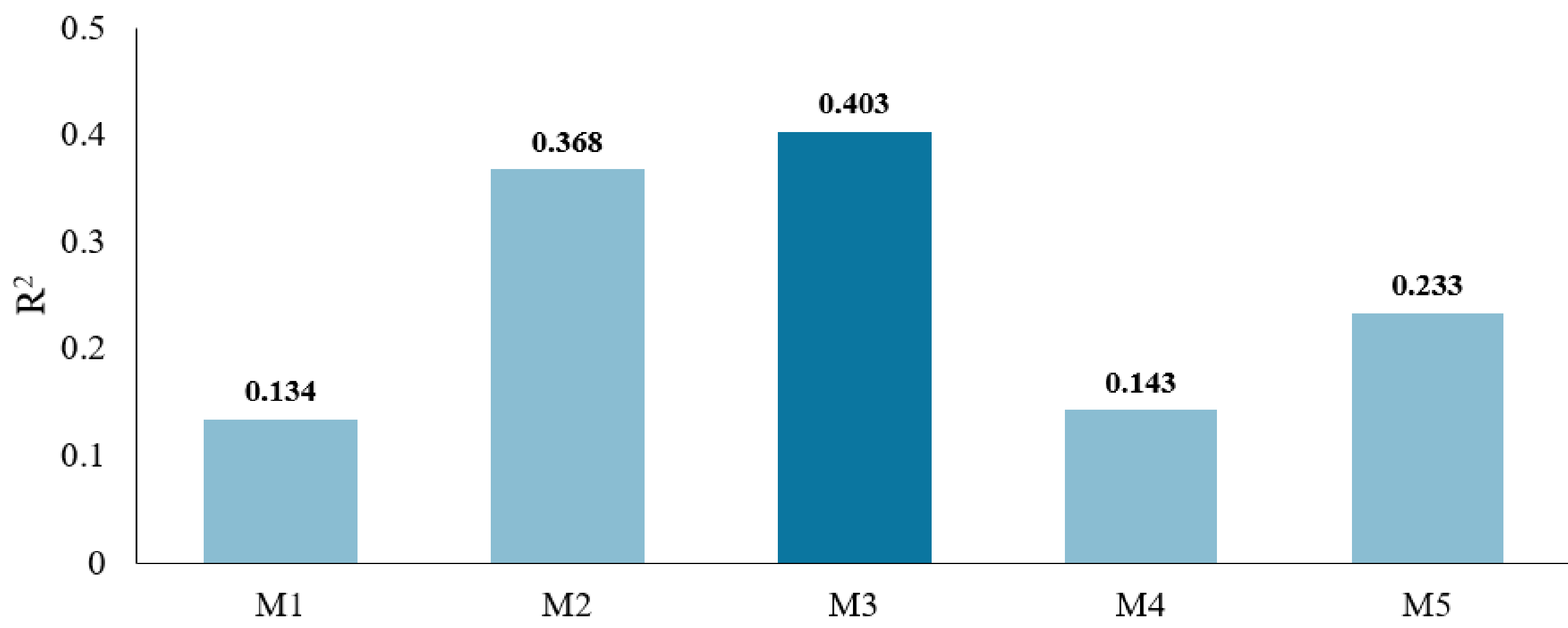


Figure 1. Model explanatory power (R^2)

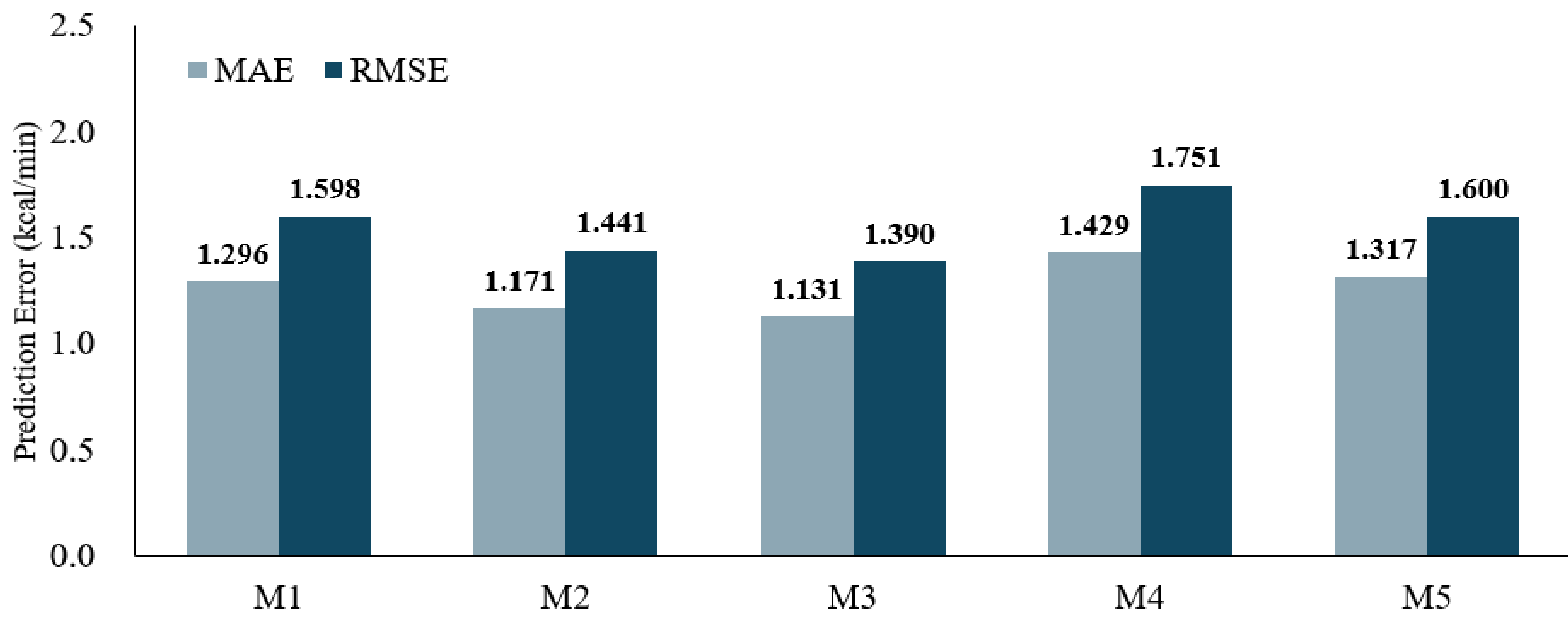


Figure 2. Prediction Errors Assessed Using LOSO-CV

Conclusion

- Combining mean HR with fat-free mass may be a useful approach for estimating EE during Taekwondo poomsae, although further refinement is needed to improve model performance.
- Independent validation in a larger and more diverse athlete population is necessary before practical application.

References

- Park KS, Jung JM. Analysis of intensity and energy expenditure Poomsae of Taekwondo practice. J Coach Dev. 2007;9(4):127–135.
- Keytel LR, et al. Prediction of energy expenditure from heart rate monitoring during submaximal exercise. J Sports Sci. 2005;23(3):289–297.

