

Normative Values of Heart Rate Recovery (HRR) After 2 Minute Step Test in Healthy Indian Population Aged 18 - 45: Cross Sectional Study

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Abstract—Background: Heart rate recovery (HRR) reflects post-exercise cardiovascular and autonomic recovery. The Two-Minute Step Test (2MST) is a submaximal field test, but reference information for HRR in healthy Indian adults is limited. **Objective:** To describe HRR following the 2MST in healthy Indian adults aged 18–45 years. **Methods:** This cross-sectional study included 431 healthy adults aged 18–45 years. Heart rate was recorded before and immediately after the 2MST and at 30 seconds, 1, 3 and 6 minutes of recovery. HRR was calculated as post-test heart rate minus heart rate at each recovery point. **Results:** Mean age was 31.39 ± 7.81 years and BMI was 22.69 ± 3.28 kg/m²; 222 participants were male and 209 females. Heart rate increased from 69.70 ± 3.90 to 141.41 ± 6.27 beats/min after testing ($p < 0.001$). Mean recovery heart rate was 127.92, 113.83, 69.93 and 69.70 beats/min at 30 seconds, 1, 3 and 6 minutes, respectively. Mean HRR was 13.49, 27.58, 71.48 and 71.72 beats/min. No significant sex or age differences were observed. **Conclusion:** The 2MST produced rapid heart-rate recovery, with most recovery occurring within three minutes. These descriptive values provide preliminary reference information for healthy Indian adults but require external validation before clinical use.

Index Terms—Heart rate recovery; Two-Minute Step Test; healthy adults; Indian population; cardiovascular recovery; normative reference; physiotherapy

I. INTRODUCTION

Heart rate recovery (HRR) refers to the reduction in heart rate after exercise has ended and is commonly used to characterize post-exercise cardiovascular and autonomic recovery. The early phase of HRR is strongly influenced by parasympathetic reactivation, while later recovery reflects additional sympathetic

and metabolic influences. Because HRR is affected by exercise modality, intensity and recovery conditions, interpretation is most meaningful when the exercise protocol and measurement timing are clearly standardized. [1–3]

The Two-Minute Step Test (2MST) is a low-cost, space-efficient submaximal test used to evaluate functional exercise capacity. Recent evidence supports its reliability in healthy adults, although familiarization and learning effects may occur with repeated administration. [4,5] Comparative work has also explored the 2MST as a practical alternative to longer step-based tests. Indian reference data for 2MST performance have been reported in healthy adults, but these studies have primarily focused on test performance rather than detailed post-exercise HRR.[6]

HRR has clinical and physiological relevance because delayed recovery has been associated with adverse outcomes in some populations, while methodological differences between exercise protocols can substantially alter the observed recovery response.[2,7] Research has also shown that body composition, physical activity, exercise modality and environmental conditions may influence autonomic recovery.[8–11] Consequently, population-specific reference information can help clinicians distinguish expected physiological recovery patterns from responses that warrant further assessment, while avoiding inappropriate transfer of reference values between different exercise tests.

Evidence from Indian studies has described HRR following other submaximal protocols and has suggested differences according to physical activity status and anthropometric characteristics. [12–14]

However, the combination of a standardized 2MST with repeated recovery measurements in healthy Indian adults aged 18–45 years has not been adequately characterized. Establishing descriptive recovery values for this age range may therefore be useful for physiotherapists working in clinical, community and exercise-testing settings.

The present study therefore aimed to describe heart-rate recovery following the 2MST in healthy Indian adults aged 18–45 years, with recovery measured at 30 seconds, 1 minute, 3 minutes and 6 minutes. Secondary objectives were to describe the pre- to post-test physiological response and examine whether recovery differed according to sex, age and BMI.

II. MATERIALS AND METHODS

Study design and participants

This cross-sectional observational study included 431 apparently healthy Indian adults aged 18–45 years. The dissertation records conventional sampling and a six-month study duration. Participants were included when they had no known medical condition and were not taking medication expected to affect heart rate. Individuals with known hypertension, diabetes, neurological impairment, lower-extremity pain, difficulty walking or standing, or medication affecting heart rate were excluded. The study population comprised 222 males and 209 females.

Ethics and consent

The dissertation records that ethical committee approval was obtained and that written informed consent was taken after the procedure was explained in an understandable language. The permission correspondence is addressed to the Principal and Ethical Committee of Ojas College of Physiotherapy, Jalna. The dissertation supplied for manuscript preparation does not state a formal ethics approval number or approval date; these details should be verified from the institutional record before submission.

Procedure

Participants performed the 2MST by stepping in place for two minutes and repeatedly raising the knee to a target marked on a wall between the iliac crest and patella. The procedure and test instructions were explained before testing. Heart rate, blood pressure,

SpO₂, respiratory rate and RPE were recorded before and immediately after the test. Heart rate was subsequently recorded at 30 seconds, 1 minute, 3 minutes and 6 minutes during recovery. A pulse oximeter was used for heart-rate measurement. Physical activity was classified using the International Physical Activity Questionnaire (IPAQ-SF).



Figure 1. Participant performing the Two-Minute Step Test (2MST) with knee elevation to the line marked at the level of the iliac crest.

Outcome definition and derived HRR

HRR was defined as the decrease in heart rate following exercise. For the present manuscript, HRR at each recovery point was calculated from the raw master chart as post-test heart rate minus the heart rate at 30 seconds, 1 minute, 3 minutes or 6 minutes. Descriptive percentile distributions were calculated from the 431 participant-level observations. These derived descriptive statistics should be independently reproduced by the authors in SPSS or another statistical package before submission.

Statistical analysis

The dissertation reports analysis in IBM SPSS Statistics version 26.0 with a significance level of $p < 0.05$. Continuous variables were summarized using mean $\pm$ standard deviation and range, and categorical

variables using frequencies and percentages. Paired-samples t-tests compared pre- and post-test physiological variables. Repeated-measures ANOVA compared heart rate across the four recovery time points, with Greenhouse–Geisser correction where appropriate. Independent-samples t-tests compared recovery heart rate between males and females. Pearson correlations examined associations of age and BMI with recovery heart rate. The present manuscript additionally reports descriptive HRR values calculated directly from the supplied master chart.

III. RESULTS

Four hundred and thirty-one participants aged 18–45 years were included. Mean age was 31.39 ± 7.81 years and mean BMI was 22.69 ± 3.28 kg/m². There were 222 males (51.5%) and 209 females (48.5%). IPAQ classification showed 336 participants (78.0%) in the moderate category and 95 (22.0%) in the high category.

Following the 2MST, mean heart rate increased from 69.70 ± 3.90 to 141.41 ± 6.27 beats/min. Respiratory rate increased from 13.45 ± 1.55 to 19.64 ± 2.06 breaths/min, and RPE increased from 6.00 ± 0.00 to 11.54 ± 1.24 . SpO₂ decreased slightly from $98.00 \pm 0.58\%$ to $97.51 \pm 0.66\%$. All reported pre-to-post comparisons were statistically significant ($p < 0.001$). Mean recovery heart rate declined progressively: 127.92 ± 6.58 beats/min at 30 seconds, 113.83 ± 7.61 at 1 minute, 69.93 ± 4.10 at 3 minutes and 69.70 ± 3.90 at 6 minutes. Repeated-measures ANOVA showed a significant effect of recovery time, $F(1.351, 581.131) = 15203.953$, $p < 0.001$. The difference between 3 and 6 minutes was small, indicating that most of the observed decline occurred during the first three minutes.

Using the participant-level post-test and recovery heart rates in the master chart, mean derived HRR was 13.49 ± 2.50 beats/min at 30 seconds, 27.58 ± 4.23 at 1 minute, 71.48 ± 7.82 at 3 minutes and 71.72 ± 7.78 at 6 minutes. The corresponding medians were 13, 28, 72 and 72 beats/min. The 5th–95th percentile ranges were 9–17, 21–35, 59–84 and 59–84 beats/min, respectively.

The dissertation reported no significant sex differences in recovery heart rate at 30 seconds ($p=0.190$), 1 minute ($p=0.074$), 3 minutes ($p=0.295$) or 6 minutes ($p=0.240$). Age was not significantly

correlated with recovery heart rate at any measured time point. BMI showed weak negative correlations with recovery heart rate at 3 minutes ($r=-0.122$, $p=0.012$) and 6 minutes ($r=-0.129$, $p=0.008$), but the magnitude of these associations was small.

Table 1. Participant characteristics

Variable	n	Mean $\pm$ SD / %	Range
Age, years	431	31.39 ± 7.81	18–45
BMI, kg/m ²	431	22.69 ± 3.28	13.3–33.2
Male	222	51.5%	—
Female	209	48.5%	—
IPAQ: moderate	336	78.0%	—
IPAQ: high	95	22.0%	—

Figure 2. IPAQ category distribution among participant

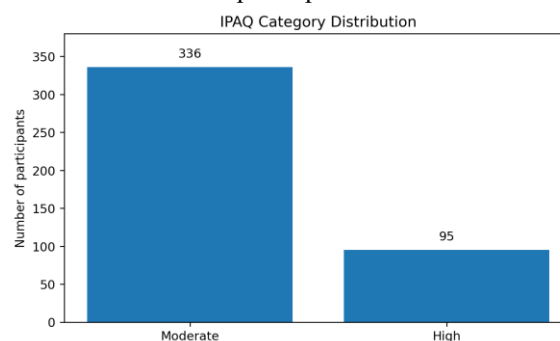


Table 2. Physiological response before and immediately after the 2MST

Parameter	Pre-test	Post-test	Mean change	p-value
Heart rate, beats/min	69.70 ± 3.90	141.41 ± 6.27	+71.72	<0.001
SpO ₂ , %	98.00 ± 0.58	97.51 ± 0.66	-0.49	<0.001
Respiratory rate, breaths/min	13.45 ± 1.55	19.64 ± 2.06	+6.19	<0.001
RPE	6.00 ± 0.00	11.54 ± 1.24	+5.54	<0.001

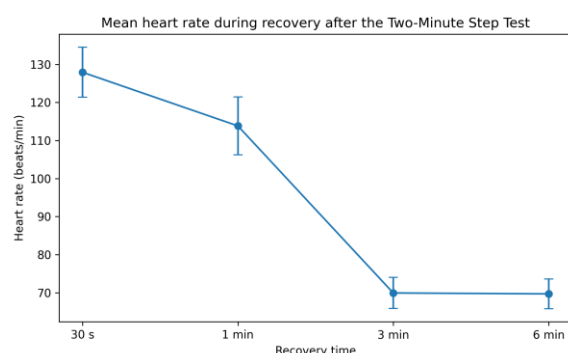
Table 3. Recovery heart rate and derived HRR

Recovery time	Heart rate, mean $\pm$ SD (beats/min)	HRR, mean $\pm$ SD (beats/min)
30 seconds	127.92 ± 6.58	13.49 ± 2.50
1 minute	113.83 ± 7.61	27.58 ± 4.23
3 minutes	69.93 ± 4.10	71.48 ± 7.82
6 minutes	69.70 ± 3.90	71.72 ± 7.78

Table 4. Descriptive percentile distribution of derived HRR

Recovery time	5th percentile	25th	50th (median)	75th	95th
30 seconds	9	12	13	15	17
1 minute	21	25	28	30	35
3 minutes	59	66	72	76	84
6 minutes	59	66	72	77	84

Figure 3. Mean heart rate during recovery after the 2MST



IV. DISCUSSION

The principal finding was a marked decline in heart rate after the 2MST, with the largest change occurring between 1 and 3 minutes. Mean recovery heart rate approached the pre-test mean by 3 minutes and was almost identical to baseline at 6 minutes. This pattern is consistent with the established biphasic nature of HRR, in which rapid early recovery is strongly related to parasympathetic reactivation. [1,2]

The 2MST is attractive for physiotherapy practice because it requires minimal space and simple equipment. Previous research has demonstrated acceptable reliability of the test in healthy adults, while Indian reference data have established expected performance values across adult age groups. [4–6] The present findings extend that literature by describing repeated post-test heart-rate responses in a healthy Indian sample rather than relying on a single recovery time point.

The derived mean HRR values increased from 13.49 beats/min at 30 seconds to 27.58 beats/min at 1 minute and approximately 71.5 beats/min by 3 minutes. The corresponding percentile distribution provides

preliminary descriptive reference information. However, these values should not be treated as diagnostic thresholds. HRR values depend on the exercise protocol, exercise intensity, posture, recovery conditions and timing of measurement, and published studies have emphasized substantial methodological heterogeneity. [2,7] External validation in independent Indian samples is therefore required before these values can be considered definitive normative standards.

No significant sex difference was observed in recovery heart rate. This is compatible with work indicating that apparent sex-related differences can depend on whether exercise is prescribed at the same absolute workload or at a comparable relative intensity. [10] Within the restricted 18–45-year age range, age was not significantly associated with recovery heart rate. This finding should be interpreted cautiously because a wider age range may reveal age-related differences that were not detectable in this sample.

BMI showed statistically significant but very small negative associations with recovery heart rate at 3 and 6 minutes. The small effect size indicates that BMI alone explained little of the variability in recovery. Previous studies have reported relationships between anthropometric measures and autonomic recovery, supporting the need to consider body composition while interpreting HRR, but not to use BMI as an isolated determinant. [8,11]

The clinical relevance of the study lies in providing a simple description of expected recovery after a standardized, low-resource exercise test in healthy adults. For physiotherapists, repeated heart-rate measurement can complement functional exercise testing and may assist in recognizing recovery patterns that differ substantially from the reference population. Nevertheless, the present values were obtained from apparently healthy participants and should not be extrapolated directly to people with cardiovascular, respiratory or metabolic disease.

V. CONCLUSION

The Two-Minute Step Test produced a substantial post-exercise cardiovascular response followed by rapid heart-rate recovery in healthy Indian adults aged 18–45 years. Recovery heart rate approached the pre-test level by approximately 3 minutes and changed very little between 3 and 6 minutes. The participant-

level data yielded mean HRR values of approximately 13.5 beats/min at 30 seconds, 27.6 beats/min at 1 minute and 71.5–71.7 beats/min at 3–6 minutes, with descriptive percentile distributions that may serve as preliminary reference information. These findings should be interpreted as population-specific descriptive values rather than diagnostic cut-offs, and should be externally validated before clinical normative use.

VI. LIMITATIONS

- Cross-sectional design prevents assessment of longitudinal change or causality.
- Participants were apparently healthy adults aged 18–45 years; findings may not generalize to younger, older or clinical populations.
- Only the 2MST was used, so recovery values may not be transferable to other exercise protocols.
- Heart rate was measured using a pulse oximeter rather than ECG.
- Recovery was sampled at four time points, leaving intervals between measurements uncharacterized.
- Day-to-day factors such as sleep, hydration, caffeine, stress and recent activity may have influenced physiological responses.
- The present study did not originally report participant-level HRR percentiles; these descriptive values were derived from the supplied master chart and require independent verification before submission.

VII. ETHICS STATEMENT

The source dissertation states that ethical committee approval was obtained and that informed consent was obtained from participants. The institutional approval number and approval date were not present in the supplied dissertation and must be verified and inserted before submission.

VIII. CONSENT FOR PUBLICATION

Written informed consent for participation was documented in the source dissertation. If any participant photographs are submitted with the article, separate consent for publication of identifiable images should be confirmed.

IX. FUNDING

No external funding was reported in the supplied dissertation. This should be confirmed by the authors.

X. CONFLICT OF INTEREST

The authors should confirm whether any conflict of interest exists. If none exists, the final submission may state: The authors declare no conflict of interest.

XI. AUTHOR CONTRIBUTIONS

The final contribution statement should be completed by the authors according to the ICMJE criteria and the actual roles performed.

XII. AI-ASSISTED WRITING STATEMENT

IJPOT currently permits AI tools only for language enhancement and requires disclosure in the Methods section. The authors should review the journal's current policy and disclose any AI-assisted language editing used during manuscript preparation. Scientific analysis and interpretation should remain the authors' responsibility.

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