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EFFECTS OF BAREFOOT ATHLETIC TRAINING ON MOTOR FITNESS VARIABLES IN RECREATIONAL MARATHON RUNNERS – A RANDOMIZED CONTROLLED TRIAL.

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Abstract - Despite the growing popularity of barefoot running, the effects of barefoot athletic training on important fitness variables of recreational marathon runners remain unclear. While some studies suggest that barefoot running may improve running economy and reduce injury risk, others have raised concerns about the potential for increased stress and fatigue. This randomized controlled trial aimed to investigate the effects of barefoot athletic training on motor fitness variables in recreational marathon runners, providing valuable insights for athletes, coaches, and clinicians. A total of 130 recreational marathon runners participated in this study, which employed a randomized controlled design. Participants were evenly divided into an experimental group (n = 65) and a control group (n = 65). Motor fitness variables were assessed at baseline and immediately following the 12-week barefoot training intervention. Data analysis utilized a combination of parametric and non-parametric tests, dependent on the normality of the data distribution. Results revealed significant improvements in motor fitness within both groups, with the experimental group demonstrating significantly greater improvements ($p < 0.001$) compared to the control group with between-group analyses. In conclusion, this randomized controlled trial provides evidence that 12 weeks of barefoot athletic training improves motor fitness variables in recreational marathon runners. The significant improvements observed in the experimental group compared to the control group suggest that barefoot training may be a valuable adjunct to traditional training programs. These findings have important implications for athletes, coaches, and clinicians seeking to optimize running performance and reduce injury risk. The study's results support the integration of barefoot training into existing training programs, and highlight the need for further research to explore the mechanisms underlying these improvements. Ultimately, this study demonstrates the potential of barefoot athletic training to enhance motor fitness and improve overall running performance in recreational marathon runners.

Key words **- Recreational marathon runners, motor fitness variables, barefoot athletic training, training for runners.**

I.INTRODUCTION

The earliest human runners almost certainly did not use footwear. There is no known archaeological or paleontological evidence that has suggested that footwear was used by early members of the genus *Homo*, who first appeared in the fossil record around 2 million years ago, or by early *Homo sapiens*, who first appeared around 200 000 years ago.(1) It has been argued that as humans evolved to run barefoot, this style of running served to minimize impact peaks and provided increased proprioception and foot strength in order to help avoid injury.(2) This barefoot phenomenon is commonly found in biblical figures, legends from the Roman and Greek era, and many works of art. The end of the “barefoot era” is still considered a relatively modern trend, as footwear only became habitual as a means to protect against acute injury, such as stepping on a sharp rock or scorching hot sand. (2) Modern barefoot running first rose to prominence in 1960, when Abebe Bikila of Ethiopia won the Olympic marathon in Rome barefoot after discovering that Adidas, the Olympic shoe supplier, had run out of shoes in his size. He was in pain because he had received shoes that were too small, so he decided to simply run barefoot. (2)

Despite the technological developments in modern running footwear, as many as 79% of runners today suffer from injuries annually. The vast majority of these injuries involve the knee, leg, and foot. Risk factors for development of running-related injury have been characterized broadly into 4 categories: systemic (age, gender, weight, knee alignment, arch type, flexibility); running or training related (training frequency/alterations/terrain, race distance, running experience, shoe age and type, pace); health (previous injury, medical problems); and lifestyle (alcohol use, smoking, cross-training). Based on this injury statistic alone, barefoot running has become an alternative method to prevent certain running injuries. (2)

Barefoot running is slowly gaining a dedicated following in developed countries around the world. Evidence of this is seen in the popularity of barefoot running Web sites and in the explosion of articles written for the popular media.(1)
A study supported the theoretical basis for barefoot running, concluding that humans evolved adaptations to optimize barefoot running, and that the biomechanics of such a style would minimize impact peaks, increase proprioception and foot strength and thus help prevent injury regardless of the choice of footwear. (03)

There remains a lack of conclusive evidence proving or refuting the proposed advantages of barefoot running, however. Such evidence will require long-term longitudinal studies and further understanding of the biomechanics and implications of barefoot running. (03)

The biomechanical justification for barefoot running centers on the concept that the differences between barefoot running is favorable and reduce the risk of injury. Therefore, it is constructive to evaluate these differences, and ask whether literature exists to support the notion that the shod-to-barefoot change results in biomechanical differences that are injury preventative. (03)

It would seem likely that habitually shod runners transitioning to barefoot running would achieve progressive changes in kinematics such as increased plantar flexion and knee flexion angle, and resultant reductions in impact force and loading rate. Accordingly, barefoot running may not be immediately effective, but rather is learned as a skill, with favorable running mechanics the result of achieving a certain skill level. (03)

Barefoot running changes biomechanics by encouraging a shorter stride and increased step rate. It has been shown that barefoot runners tend to have a decrease in stride length, despite controlling for running speed. This has been shown to decrease vertical loading rate compared to shod runners. It has also been shown that compared to barefoot running, shod running elevates torques at the knee and hip joints, over and above what is expected through adaptations in stride length and cadence. Modern-day running shoes increase joint torques
throughout the lower extremity. This increase is likely caused by in part the elevated heel and increased material under the medial aspect of the foot. (04)

Many studies have been done on barefoot training and change in running biomechanics after barefoot training but there is lack of evidence available which clearly explains the effect of barefoot training on muscle and cardiovascular endurance, muscle strength and balance after barefoot training.

Hence, this investigation aimed to implicate shod to barefoot running conversion training and also to provide 12 week barefoot athletic training to recreational marathon runners and thereby to evaluate the effects on above stated parameters to address a significant gap in the current literature.

- **Alternative hypothesis -** Barefoot training significantly improves muscle and cardiovascular endurance, muscle strength, balance and also reduces prevalence, frequency and severity of common musculoskeletal injuries than conventional training alone in recreational marathon runners.

- **Null hypothesis -** Barefoot training does not provide any additional benefit than conventional training alone in improvement of muscle and CVS endurance, muscle strength, balance and in reduction of prevalence, frequency and severity of common musculoskeletal injuries in recreational marathon runners.

II.MATERIAL & METHODS

- **Research approach:** Quantitative.
- **Study Design –** A Randomized Controlled Trial.
- **Research setting:** Shrimad Rajchandra College of Physiotherapy, Uka Tarsadia University, Maliba campus, Bardoli, Surat, Gujarat, India.
- **Research population:** Recreational marathon runners.
- **Study duration –** 5 months.
- **Selection criterion (7)(9)(12) –**

❖ **Inclusion criterion -**

✓ Male participant.
✓ 18-40 years of age.
✓ Participant with normal ROM in all body joints.
✓ Participant should be running at least 15 km per week.
✓ Participant capable of completing 2.4 km time trial test in under 10 to 12 minutes.
✓ Should have completed at least 1 half or full marathon.
✓ Should be involved in running program from at least 6 months.
✓ Participant being able to read, understand and write English language comfortably.

❖ **Exclusion criterion –**

✓ Participants will be excluded if they have a history of invasive surgery to the back, pelvis or lower extremities in the previous year.
✓ If they use any orthotics in their running shoes.
✓ Those who have participated in any training related to barefoot running.
✓ History of any neurological condition in past and having sensory/motor/autonomic deficit.
✓ Any lower limb deformity.
✓ If they are unable to perform intervention program.

- **Sample size –** 130 (effect size = 0.5, α value = 0.05, Power = 0.80, allocation ratio = 1, drop outs = 10%)
- **Sampling method –** Purposive Sampling
- **Data collection tools –** Stopwatch, cones, Handheld dynamometer, Mat, Measure tape, Transparent sticking tape, Scale.

- **Detailed procedure of study –** After obtaining ethical approval, samples were gathered from Surat city and neighboring districts based on selection criterion. Informed signed consent was obtained from participants, who completed a Self-Administered Questionnaire (SAQ) providing demographic characteristics and confirming eligibility based on inclusion and exclusion criteria. All outcome measures were assessed at baseline before participants were randomly allocated to either the Intervention group (Group 1) or Control group (Group 2). The intervention consisted of 1 week of preparatory activities followed by 12 weeks of barefoot running, performed 3 days a week (along with normal routine training). Post-intervention outcome measures were then collected.
- **Intervention protocol –**

- Protocol for warm up before each session of intervention –

1. Jumping jacks (10 repetitions),
2. Forward-walking lunges (10 steps),
3. Reverse-walking lunges (10 steps),
4. Mountain climbers (10 repetitions), and
5. Easy jogging (3 minutes). (42)

Preparatory activities for barefoot running	
Barefoot activity	Barefoot walking indoors
	Barefoot walking outdoors
	Barefoot running indoors
	Barefoot running outdoors—progress from grass to asphalt
Running form drills (Figure 2)	Forefoot striking
	Increased cadence
	Shorter step length
Proprioceptive exercises (Figures 3, 4)	Single-leg stance
	Single-leg stance on ankle disc/wobble board
	Single-leg stance with resistive band
Flexibility exercises (Figure 5)	Calf stretching against wall
	Calf stretching off the edge of a step
	PNF calf stretching
Strengthening exercises (Figures 6, 7)	Foot intrinsics
Plyometric activities (Figures 8–10)	Hops (single-leg forward hops, single-leg hurdle hops)
	Jumps (squat jumps, split scissor jumps, depth jumps, double/single-leg hurdle jumps)
	Bounding in horizontal and vertical planes (double-leg bounds, alternate leg bounds)

Protocol for Week 0(Shod to barefoot conversion training), three sessions in week 0

- 12 Week barefoot training protocol(5) – A gradually progressive protocol was modified and used for barefoot athletic training starting from 30 minutes of low intensity walk & run to 60 minutes of moderate to intense running for the intervention group along with their routine training. Participants of control group continued their routine running training.
- **Outcome measures -**

1. Cooper 2.4 km run test(Cooper) (24) (28)
2. Maximum voluntary isometric contraction(MVIC) of Hip Extensors(HE), Hip Abductors(HAB), Knee Extensors(KE), Ankle Planter flexors(APF) (26)
3. Y - balance test(YBT) (25)(27)(30)
4. Muscle endurance(ME) for lower quadrant – Modified Squat Test (29)
5.

III.DATA ANALYSIS

The data was analyzed using SPSS version 23. Normality testing was conducted which suggested that the data isn't normally distributed in all except for one outcome measure that is cooper 2.4 km run test. Hence the analysis was conducted with non-parametric tests for data of all outcome measure except for cooper 2.4 km run test. For cooper 2.4 km run test, the data was analyzed with parametric test. In the non-parametric analysis independent sample Mann-Whitney U test & related sample Wilcoxon signed rank test were used for between & within group analysis respectively. In addition for parametric analysis independent sample 't' test and paired 't' test were used for between & within group analysis respectively.

IV.RESULTS AND DISCUSSION

Table 3.1: Descriptive statistics.

Variable	Grp	Mean	Median	SD	Sig.
Age (Years)	1	24.28	24.00	3.881	**0.74**
	2	24.54	25.00	4.255	
Limb length (cm)	1	94.26	94.00	7.388	**0.42**
	2	93.71	93.00	7.355	
BMI (Kg/m^2)	1	23.04	23.20	1.223	**0.66**
	2	23.10	23.40	0.553	

*Grp=Group

Table 3.1 displays descriptive statistics of age, limb length and Body mass index (BMI) of both the group and values between the groups are not having significant difference (Level of significance ≤ 0.05).

Table 3.2: Results of between group analyses.

Variables	Analysis	Sig.
Cooper, ME, MVIC-HE, MVIC-HAB, MVIC-KE, MVIC-APF, Normalized anterior, posteromedial, posterolateral and composite reach of YBT.	Between group comparison Post Intervention	**0.000**

Table 3.2 displays the results of between group analysis and the values are suggesting that a between group difference exists.

Table 3.3: Results of within group analyses.

Variables	Analysis	Sig.
Cooper, ME, MVIC-HE, MVIC-HAB, MVIC-KE, MVIC-APF, Normalized anterior, posteromedial, posterolateral and composite reach of YBT.	Within group comparison (for group 1 and 2)	**0.000**

Table 3.3 displays the results of within group analysis and the values are suggesting that both the groups improved significantly in within group analysis.

From the mean, median and value of significance it was interpreted that both the groups improved significantly when analyzed for within group comparison with parametric and nonparametric tests. In between group comparison the results of analysis suggested that there is significant difference between the data of both the groups and the intervention group was found to be significantly better in all the tested parameters. ($p < 0.001$)

Barefoot running is slowly gaining a dedicated following in developed countries around the world. Evidence of this is seen in the popularity of barefoot running Web sites and in the explosion of articles written for the popular media.(1) The present study included a total of 130 recreational marathon runners who were divided into 2 groups. One group performed barefoot training program along with their conventional training whereas another group continued their routine conventional training. Outcome measures were taken before and just after the intervention which suggested that both the group improved in all tested parameters after 12 weeks of training specifically the interventional group improved significantly better in all tested parameters when compared to control group. The significantly better improvements in interventional group was achieved by many of the known benefits of barefoot training. So far many studies have been done which all has described that barefoot training improves biomechanics of running(14), reduces injuries(6), improves foot morphology(6), improves running economy(5) and many additional benefits, but there is lack of evidence available which clearly shows improvement in actual running related motor fitness variables and skills. Hence current study addressed that particular gap of evidence in the field and intended to connect the basic mechanical improvements which were already proven to the improvement in actual running related skills.

Though follow-up assessments were not done for any of the outcomes to observe washout or deconditioning of the achieved benefits. Actual changes in the injury prevalence, frequency and severity were also not assessed. So, future studies can focus on a long term study with follow up assessments of all outcomes measures and a separate study can also be done to check the effects on injury prevalence, frequency and severity of the intervention on recreational marathon runners.

V.CONCLUSION

In conclusion, this study provides novel evidence that barefoot training significantly improves running-related motor fitness and skills in recreational marathon runners. The significant enhancements in the interventional group, compared to the control group, suggests that barefoot training can be a valuable adjunct to conventional training programs. Notably, this study addresses a significant gap in the literature by demonstrating the transfer of basic mechanical improvements to actual running performance. These findings have important implications for athletes, coaches, and clinicians seeking to optimize running performance in recreational marathon runners.

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Conflicts of Interest – *None.*

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