Rochester Institute of Technology

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Multidisciplinary Senior Design

P17025: Portable Toddler Treadmill Project

Quality Control

Testing Plan & Procedure For Conformity to Engineering and Safety Requirements

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1. INTRODUCTION/SCOPE:

This document will provide a complete testing procedure for the Portable Toddler Treadmill project, done as a part of Multidisciplinary Senior Design Program at Rochester Institute of Technology. The porject details can be found on the the following link: https://edge.rit.edu/edge/P17025. This document is intended to be applied on the components, or the entirety of, the treadmill, as applicable. This document is written and revised as a part of an academic project, and as such, the testing plan and procedures may differ significantly, should the document be professionally revised.

2. STANDARDS REFERENCES, DISCLAIMER:

This document and the testing plan and procedure contained herein, are heavily influenced, or based upon, the standards shown in Table 1 below.

Organization	Reference Code	Title of Standard
ASTM, Inc.	**Designation: F2115 − 12**	**Standard Specification for Motorized Treadmills.**
ASTM, Inc.	**Designation: F1749 − 15**	**Standard Specification for Fitness Equipment and Fitness Facility Safety Signage and Labels**
ASTM, Inc.	**Designation: F2106 − 12**	**Standard Test Methods for Evaluating Design and Performance Characteristics of Motorized Treadmills.**
ASTM, Inc.	**Designation: F2571 - 15**	**Standard Test Methods for Evaluation Design and Performance Characteristics of Fitness Equipment**
International Standards Organization (ISO)	**ISO-20957-6**	**Part 6: Treadmills, additional specific safety requirements and test methods**
International Standards Organization (ISO)	**ISO-20957-1**	**Stationary Training Equipment -- Part 1: General Safety Requirements and Test Methods**

Table 1: Adopted Standards

The testing procedure, therefore, will be generally confirming to the standards shown in Table 1. As such, the order of procedures, and the testing components, will, generally, corresponds to those in the standards.

Disclaimer: Although that, to the extent possible, this testing procedure tries to adapt to the standards shown in Table 1, due to the nature and engineering requirements of this project, the

testing values, and/or, testing procedures has been adjusted for the purposes of this project. Therefore, the standards shown in Table 1 have been considered points of reference only.

3. DEFINITIONS:

Unless otherwise indicated herein, the following definition apply in this document:

- Treadmill/Device: means the assembled portable toddler treadmill resulting from this project.
- Child: means the end user, generally, children with disabilities under the age of 2 years.
- Guardian: means the parent(s), therapist, or any other adult supervising the use of the treadmill.
- Component: any specified, or unspecified, mechanical, electrical, or safety components, assembled within, or part of, the treadmill.
- Engineering Requirement ("ER"): the finalized specifications adopted by the engineers/designers involved in this project.
- Defective component(s)/part(s): when stated, a defective components means any mechanical, electrical, or safety components that fails to conform to an expected behavior , or fails to meet any ER.
- Nonconforming components: usually considered less than a defective components, means any part that fails to meet a certain requirement(s), but a sufficiently simple corrective action can be undertaken to allow for conformity.

4. UNITS OF MEASURE:

The International Systems of Units (SI) is used in all testing plans/procedure. In some cases, Imperial units are provided for reference only, which will be contained between square brackets, (e.g., [x.xx lbs]).

5. TESTING PREPARATION:

Treadmill: To conduct the test, complete the assembly process for the treadmill. Ensure that all components are adequately held into their design-intended positions. Moving surfaces (e.g., belt) should be brought to the level of tension required. Connect treadmill to a power source, and conduct a dry run to confirm that the treadmill is working adequately.

Environment: The testing environment should offer sufficient space to operate the treadmill safely. Also, it should be free from any factors that can affect the results of the

testing. Testing should be done in a temperature-controlled room at room temperature, i.e., between 15 °C [59 °F] and 30 °C [86 °F].

Unless stated otherwise, once the treadmill is ready for testing, all of the testing procedures should be conducted without altering the initial conditions (e.g., mid-test repair of a part/components).

6. TESTING DOCUMENTATION AND CRITERIA:

Testing should be done with adequate documentation. It is suggested that the tester(s) develop a "checklist" based on this document to ensure all of the testing procedures has been followed. Unless otherwise stated, the testing procedure is done on pass or fail basis.

7. TEST PROCEDURE FOR TREADMILL:

7.1. *Stability*: The treadmill should be tested for stability in a condition where it is expected to be unstable. To conduct the testing for stability, the following equipment will be needed:

- Deadweight equal to, or slightly greater than, the maximum user weight as per ER.

Then, perform the following steps:

7.1.1. Place the treadmill on a non-sliding surface, the treadmill should be OFF.

7.1.2. Apply the deadweight vertically onto the treadmill's foot rails. The application of deadweight should be steady (non-impact). The positions on the foot rails should be multiple points that would create possible instability. The treadmill should not tip, or move, in any direction.

7.2. *Exterior Mechanical Components:* The purpose of this test is to ensure that accessible mechanical/moving parts by a child or a guardian do not create a safety hazard. To conduct this test, the following equipment will be needed:

- Testing prope that simulate a human finger. The testing probe should be no more than 90mm [3.5in] long.

Then, perform the following steps:

7.2.1. Locate any possible mechanical hazards on the treadmill. This includes, but not limited to, motor enclosure, gap between foot rails and belt, and guards to rollers on the front and back ends of the treadmill, collectivity "accessible areas".

7.2.2. With the treadmill OFF, insert the testing probe into all possible accessible areas. At each of those areas, rotate and bend the testing probe in a motion that will simulate a human motion. Testing probe should be applied with a force not to exceed 4.4N [1lb].

7.2.3. At each of the accessible areas, while the testing probe is inserted, turn the treadmill ON at minimum belt speed. That is, between each accessible area, turn the treadmill OFF before moving to the next area.

7.2.4. The testing probe should not, at any accessible area, become entrapped. Entrapment occurs when the force needed to remove the probe exceeds the force of insertion (i.e., 4.4N).

7.3. *Electrical Hazards:* Using the same testing probe described in 7.2., conduct the following test:

7.3.1. Locate any possible openings in the enclosure of the treadmill that will direct to an electrical component(s).

7.3.2. With the treadmill OFF, insert the testing probe into all of the possible openings. At each possible opening, the probe should be rotated and bent in all possible directions.

7.3.2. Testing probe should not be able to reach (i.e., touch) any electrical components.

7.4. *Moving Surface Slip (Belt):* The purpose of this test is confirm that the belt has adequate resistance to slipping when wet. Conducts as follows:

7.4.1. Restrain the belt from moving, treadmill OFF.

7.4.2. Spray the belt with water. Caution for the water not to damage any components.

7.4.3. A tester should be able to stand and perform one step movement horizontally without feeling a slip away from the treadmill. Use caution when conducting this test. A person, other than the tester, should be present to assist.

7.4.4. Dry the belt completely before conducting any further testing.

7.4.5. Once the belt is dry, turn treadmill ON.

7.4.6. Observe regular operation for at least 60 seconds, then turn OFF the treadmill. A belt that does not offer sufficient slippage resistance will fail this test.

7.5. *Endurance Testing:* The purpose of this test is to confirm that all treadmill components will exhibit sufficient endurance under specific conditions. To conduct the testing, the following equipment will be needed:

- Timing-controlled load application device (“LAD”)

Then, perform the following steps:

7.5.1. Place the LAD at the centerline of the treadmill, at approximately ⅓ of the length of the belt (rear-end) . Use sufficient space for the LAD to be operating correctly.

7.5.2. With the treadmill OFF, using supporting equipment, ensure that the treadmill will not move from place when the LAD is operating (due to vibrations).

7.5.3. Based on the ER, calculate appropriate loading increments over a specific time period and frequency of application of such loads. The load should reach at least 1.5 times maximum user weight. The test should run for at least 5 minutes.

7.5.4. Turn on the LAD, and apply loads based on the calculations done in 7.5.3.

7.5.5. Upon completion of this test, the frame, and other structural components, should not exhibit any signs of cracks, mechanical system failure, or movement of belt.

7.6. *Controls:* The following test is intended to examine the functions of all implemented controls on the treadmill. Controls include the emergency stop button, speed adjustment pedals, safety key, and the feedback display. To conduct the following test, the following equipment will be needed:

- Stopwatch.
- Calibrated Speedometer, which can measure speed of belt.

Then, perform the following steps:

7.6.1. Bring the treadmill to a normal position.

7.6.2. With the safety key disengaged, try to turn ON the treadmill. Treadmill should NOT operate any function.

7.6.3 Engage the safety key.

7.6.4. Turn the treadmill ON, at a speed equal to, or greater than, 0.22 m/s [0.5MPH].

7.6.5. Once the treadmill reaches the speed, measure the speed using an external speedometer. The reading should be accurate within 1% of the chosen speed.

7.6.6. While the treadmill is in motion, decelerate incrementally to a full stop.

7.6.7. Accelerate again to the maximum speed the treadmill can reach. Record time of acceleration to maximum speed. Confirm speed using speedometer to ER.

7.6.8. When the speed is reached, sustain speed for at least 40 seconds.

7.6.9. Press on the emergency stop button. Record time. The belt must come to a full stop, while accelerating at a safe pace, within a time segment that is less than the acceleration time.

7.6.10. Using speedometer, and if available and needed, other measurements instruments, confirm feedback display readings with those external instrument. Reading should match within 1% for speed, and 5% for all other readings, if applicable (e.g.., weight, Heart Rate Monitor, etc.).

7.7. *Static Loading:* The purpose of this test is to check the maximum allowance of load that the structure of the treadmill can hold without exhibiting a sign of nonconformity on the mechanical structure. To perform this test, the following equipment will be needed:

- Deadweight that is equal to approximately 3 times the maximum weight of the user.

Then, perform the following:

7.7.1 With the treadmill OFF, apply load on the centerline of the treadmill on the belt. The load should be applied in a manner which simulates a child (user position).

7.7.2. Sustain load on position for a sufficient time, between 5 to 15 seconds.

7.7.3. Remove the load.

7.7.4. Apply the load on the foot rails (both sides). Sustain load on each side for a sufficient time, between 5 to 15 seconds.

7.7.5. Remove load, then check all components of the treadmill for any signs of impending failure of the mechanical system, cracks, separations, or structural failure. If any of those signs are found, the treadmill fails this test.

7.8. *Overheating:* This test is performed to check the temperature of the treadmill components under high usage conditions. To conduct this test, the following equipment will be needed:

- Appropriate Temperature Measuring System ("TMS").
- Load application device (LAD).

Then, perform the following:

7.8.1 Using the LAD, apply a load that is equal to the maximum user weight.

7.8.2. Using the TMS, while the treadmill is OFF, all components temperature should be at ambient temperature.

7.8.3. Turn ON the treadmill, while LAD is applied, incrementally raising speed up to the maximum, while using the TMS to read the temperature on multiple points on the treadmill. Sustain load for at least 3 minutes.

7.8.4. The TMS readings from part 7.8.3 should not exceed 60 °C [140 °F] for all metallic surfaces, and 85 °C [185 °F] for non-metallic surfaces.

7.8.5. Repeat the test at least 3 times to ensure consistency.

7.9. *Compliance in Labels and Documents:* This test is intended to check the installed labeling and accompanying documentation confirm to standards. Perform as follows:

7.9.1. Check all labeling on the treadmill itself, and compare to ASTM standard F1749-15 (see Table 1).

7.9.2. Check user's manual. All necessary information for user should be written legibly and in a language that is common and easily understandable by Guardians.

8. ERGONOMICS OF HANDLING TESTING:

8.1. *Introduction*: This portion of the document is intended to provide an auxiliary testing that will ensure that the treadmill is safe for handling by guardians. Mainly, this test will ensure that, for the average guardian, the lifting and moving of the treadmill will not cause any back [physical] pain. To conduct this test, the following equipment will be needed:

- Accurate scale that can measure the weight of the treadmill.
- Measuring tape.
- Angle Measurement Instrument.

The ergonomic testing is based on The National Institute for Occupational Safety and Health (NIOSH) lifting equation which determines the Recommended Weight Limit (RWL) and the Lifting Index (LI), both of which provide indication of any possible risk of fatigue or physical discomfort that can be imposed on the guardians. Table 2 below provides a detailed explanation of the NIOSH lifting equation and its components.

NIOSH EQUATION	$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$	
Term	**Definition**	**Assigned Value**
LC	Load Constant: maximum weight that can be lifted under ideal cirumictanses.	23 kg [50 lbs].
HM	Horizontal Multiplier: Horizontal displacement, *H*.	25/H [10/H]
VM	Vertical Multiplier: Vertical Distance from ground, *V*.	$(1 - 0.003 \mid V - 30 \mid)$
DM	Distance Multiplier: Vertical Distance of Lifting, *D*.	$(0.82 + 4.5/D)$
AM	Asymmetric Multiplier: Angle of torso twisting during lifting, *A*.	$(1 - 0.0032A)$
FM	Frequency Multiplier: The frequency of lifting action	From NIOSH Tables (Constants) - See Appendix A

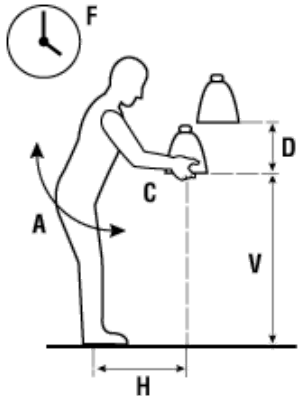
	during a day (time unit).	
CM	Coupling Multiplier: The quality of coupling determines the coupling constant, *C*.	For $V < 75$ cm [30 in]: C = 1 for Good Coupling C = 0.95 For Fair Coupling C = 0.90 For Poor Coupling For $V > 75$ cm [30 in]: C = 1 For Good and Fair Coupling C = 0.90 for Poor Coupling
Graphical Representation of NIOSH Components[1]		

Table 2: NIOSH Lifting Equation

Upon attainment of the values shown in Table 2, i.e., RWL, the LI can be calculated as follows:

$$LI = (Weight\ of\ Treadmill) / RWL \quad \text{..... (1)}$$

The physical risks is then indicated by the value of *LI*. For a value of LI that is greater than 1, the lifting of the treadmill will pose an increased risk of physical discomfort or injury. Value greater than 3, many guardians are at higher risk. Ideally, the value of *LI* should between 0 and 1.5.

8.2. *Test Procedure:* based on the information presented in 8.1., perform the following:

8.2.1. Weigh the treadmill on a scale accurate within ± 1kg.

8.2.2. Place on the treadmill on the ground, then measure and calculate the needed values to evaluate the components of the NIOSH equation shown in Table 2.

8.2.3. Calculate the RWL.

8.2.4. Use the RWL and the actual weight to evaluate *LI* as per equation (1).

8.2.5. The obtained *LI* should not exceed a value of 3. If the value does in fact exceed 3, expected handlers of the treadmill should be adequately informed to refrain from

[1] Image retrieved via Google Images. Direct Link: http://images.ccohs.ca/oshanswers/MMH050.gif.

excessive handling during a short period of time. Assistive handling devices (e.g., moving cart) could be suggested.

APPENDICES

Appendix A: NIOSH Lifting Equation Multipliers

Horizontal Multiplier

H	HM	H	HM
in		cm	
≤ 10	1.00	≤ 25	1.00
11	0.91	28	0.89
12	0.83	30	0.83
13	0.77	32	0.78
14	0.71	34	0.74
15	0.67	36	0.69
16	0.63	38	0.66
17	0.59	40	0.63
18	0.56	42	0.60
19	0.53	44	0.57
20	0.50	46	0.54
21	0.48	48	0.52
22	0.46	50	0.50
23	0.44	52	0.48
24	0.42	54	0.46
25	0.40	56	0.49
> 25	0.00	58	0.43
		60	0.42
		63	0.40
		>63	0.00

Vertical Multiplier

V	VM	V	VM
in		cm	
0	0.78	0	0.78
5	0.81	10	0.81
10	0.85	20	0.84
15	0.89	30	0.87
20	0.93	40	0.90
25	0.96	50	0.93
30	1.00	60	0.96
35	0.96	70	0.99
40	0.93	80	0.99
45	0.89	90	0.96
50	0.85	100	0.93
55	0.81	110	0.90
60	0.78	120	0.87
65	0.74	130	0.84
70	0.7	140	0.81
> 70	0.00	150	0.78
		160	0.75
		170	0.72
		175	0.70
		> 175	0.00

Distance Multiplier

D	DM	D	DM
in		cm	
≤ 10	1.00	≤ 25	1.00
15	0.94	40	0.93
20	0.91	55	0.9
25	0.89	70	0.88
30	0.88	85	0.87
35	0.87	100	0.87
40	0.87	115	0.86
45	0.86	130	0.86
50	0.86	145	0.85
55	0.85	160	0.85
60	0.85	175	0.85
70	0.85	> 175	0.00
> 70	0.00		

Asymmetric Multiplier

A	AM
deg	
0	1.00
15	0.95
30	0.90
45	0.86
60	0.81
75	0.76
90	0.71
105	0.66
120	0.62
135	0.57
> 135	0.00

References

1. Marshall, M. “NIOSH Lifting Equation” class presentation. Retrieved from myCourses: ISEE330, Spring 2016.
2. ASTM International, 2016, “Standard Specification for Fitness Equipment and Fitness Facility Safety Signage and Labels”. F1749-15.
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4. ASTM International, 2016, “Standard Test Methods for Evaluating Design and Performance Characteristics of Fitness Equipment”. F2571-15.
5. Waters T, et. al. 1994. “Application Manual For the Revised NIOSH Lifting Equation”.
6. International Standards Organization (ISO), 2016, “Treadmills, additional specific safety requirements and test methods”. ISO-20957-6.
7. International Standards Organization (ISO), 2016, “Stationary Training Equipment - Part 1: General Safety Requirement and Test Methods ”. ISO-20957-1.