ME 1.07 - Sit-to-Stand Training Device

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Project Description

Our mission is to develop a safe, ergonomic, and cost-effective sit-to-stand assistive mobility device that enhances patient independence, reduces fall risk, and supports rehabilitation during physical therapy.

Sit-to-Stand Phases

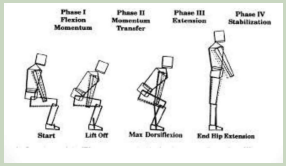


Figure 1: Four Phases of the Sit-to-Stand Transition

Customer Needs

- **Safety:** Wherever there is potential harm, we must be there to protect.
- **Adjustability:** Able to accommodate the widest array of patient types.
- **Psychological:** Promote progression and pride during training.
- **Comfort:** Ergonomic design
- **Operation:** Enable specificity throughout the sit-to-stand transition
- **Storage:** Be mindful of the therapy departments' real estate.
- **Expense:** The training device offers competitive pricing.

Target Specifications

Qualitative Holder Feedback → Measurable Metrics → Competitive Benchmarking

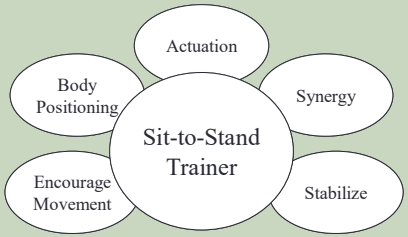
Specification	Importance	Unit	Benchmark Target
FDA Class I MD Reg.	5	Binary	Yes
Specificity	5	N/A	Yes
Trunk Muscle Support	4	Θ	10 ~ 30
Moment of Inertia	3	$kg \cdot m^2$	12 ~ 20
Activation Force Threshold	2	N	10 ~ 200

Table 1: Examples of target specifications

Stakeholders

1. TXST Physical Therapy Dep.
2. Physical Therapists
3. Regulatory Agencies
4. Healthcare Institutions

Subsystem Classification



Concept Generation

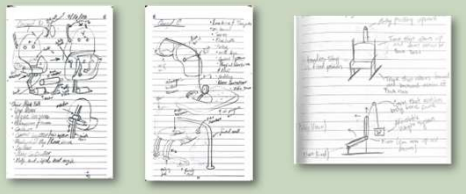


Figure 2: Top three concepts generated

- TRIZ Methodology
- Gallery Method
- Classification Tree Pruning

Concept Selection

Criteria Topic	Criteria	Weight	Weight2	IG Score	IG Weighted Score	XKM Score2	XKM Weighted Score2
Patient Safety		25%					
	Injury Risk		10%	2	0.20	3	0.30
	Stable		8%	2	0.16	3	0.24
	Secured		7%	2	0.14	3	0.21
Specificity		24%					
	Mimic Gait		8%	5	0.40	3	0.24
	Muscle Group Targeting		8%	4	0.32	4	0.32
	Body Type Applicability		8%	4	0.32	4	0.32
Ease of Use		8%					0.00
	Intuitive Control		4%	3	0.12	4	0.16
	Clear Instruction		4%	3	0.12	4	0.16
Patient Comfort		9%					
	Ergonomic Seat		3%	3	0.09	3	0.09
	Ergonomic Attachment Points		3%	4	0.12	3	0.09
	Smooth Ride		3%	2	0.06	3	0.09
Variability		14%					
	Variable Assisting Load		7%	3	0.21	3	0.21
	Variable Resisting Load		7%	3	0.21	3	0.21

Figure 3: Sample of concept scoring matrix

Final Concept

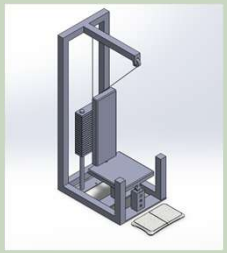


Figure 4: Final CAD model in down configuration

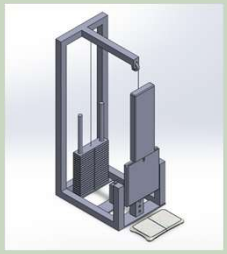


Figure 5: Final CAD model in up configuration

Key Design Details

- Variable Assisting Load
- Closed Loop Feedback System
- Mimics Gait
- Intuitive Control
- Smooth Ride
- Floor Real Estate
- Time to Set Up
- Muscle Group Targeting

The system is designed around a cushioned seat integrated with a pulley and adjustable weight system, which helps straighten the chair into an upward position to effectively lift the user. To provide active assistance during the sit-to-stand motion, a linear actuator pushes upward on the seat to help encourage user movement. This mechanical setup is enhanced by a closed-loop system featuring a Wii Balance Board, which allows the device to sense the patient's weight distribution and determine exactly how much assistance the linear actuator should provide. Finally, the design incorporates shoulder straps and knee supports to ensure the load is safely and evenly distributed across the user's body throughout the movement.

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Key Design Challenges

- Specificity
- Torque Profiles
- Safety
- Actuation

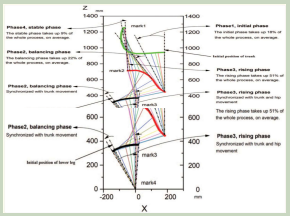

Figure 6: Schematic drawing of division principle

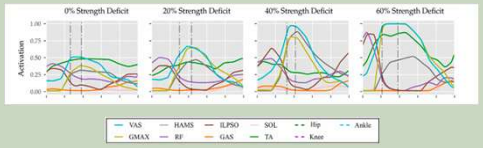

Figure 7: Muscle activation for varying strength deficits

Future Steps

- Identifying fundamental and incidental interactions.
- Complete specification of the geometry, materials, and tolerances
- Testing and refinement
- Production ramp-up

References

[1] Kumar V, Yoshiike T and Shibata T (2022) Predicting Sit-to-Stand Adaptations due to Muscle Strength Deficits and Assistance Trajectories to Complement Them. Front. Bioeng. Biotechnol. 10:799836. doi: 10.3389/fbioe.2022.799836

[2] Millington, P. J., Myklebust, B. M., and Shambes, G. M., "Biomechanical Analysis of the Sit-to-Stand Motion in Elderly Persons," Archives of Physical Medicine and Rehabilitation, Vol. 73, No. 7, pp. 609–617, 1992.

[3] Li, J., Xue, Q., Yang, S., Han, X., Zhang, S., Li, M., and Guo, J., "Kinematic Analysis of the Human Body During Sit-to-Stand in Healthy Young Adults," Medicine (Baltimore), Vol. 100, No. 22, 2021