DRUK- EN SCHUIFKRACHTEN IN DE HANDBIKE EN ROLSTOEL

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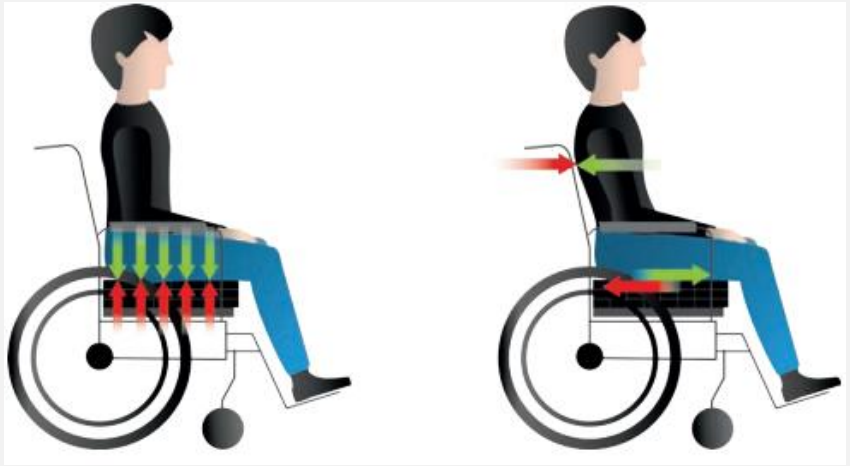
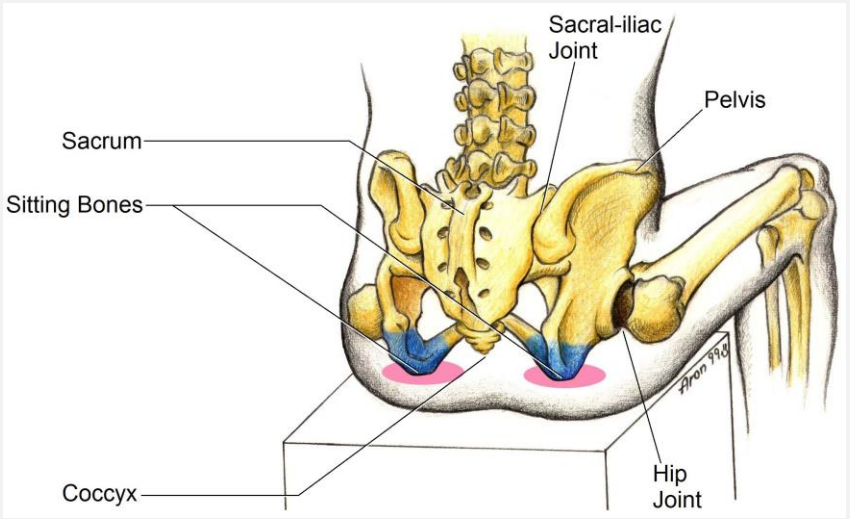
DWARSLAESIE

- Verhoogd risico: één op de drie ontwikkelt decubitus
  - Continue belasting van het zitvlak
  - Hogere druk- en schuifkrachten
  - Verminderde mobiliteit en sensibiliteit
  - Verminderde doorbloeding en spiermassa
- Verminderde kwaliteit van leven
- Risicogebieden: Sacrococcygeal (SC) en ischial tuberosities (IT)



Figuur1. De druk (links) en schuif (rechts) krachten



Figuur 2. De risico gebieden (IT & SC)

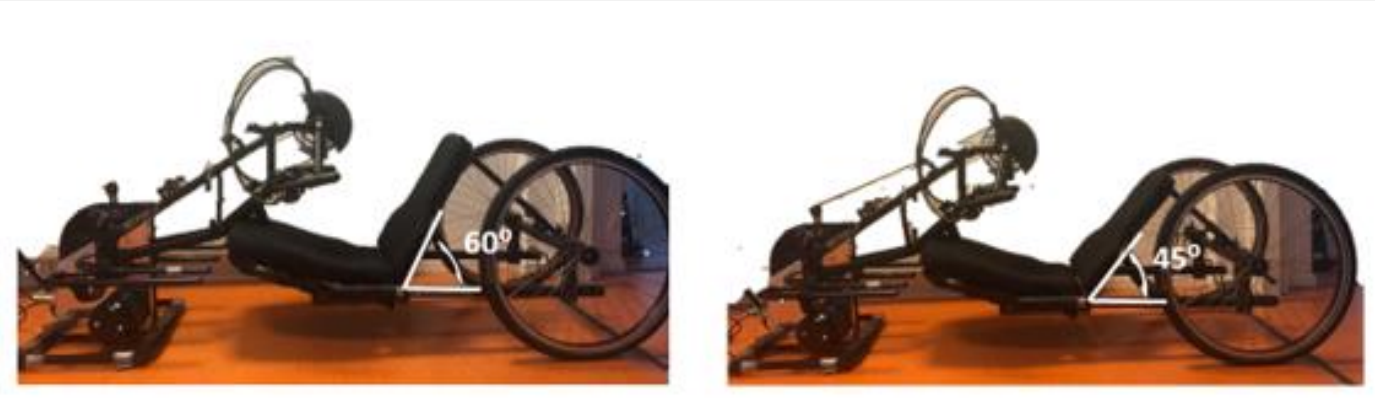
RELEVANTE PARAMETERS

- Rolstoel en handbike
  - Hogere prevalentie decubitus in handbike
  - Weinig bekend over druk- en schuifkrachten in de handbike
- Aanpassen rugleuninghoek handbike
  - Invloed hoek onduidelijk
- Aanpassen kussen
  - Standaard handbike kussen tijdens de battle

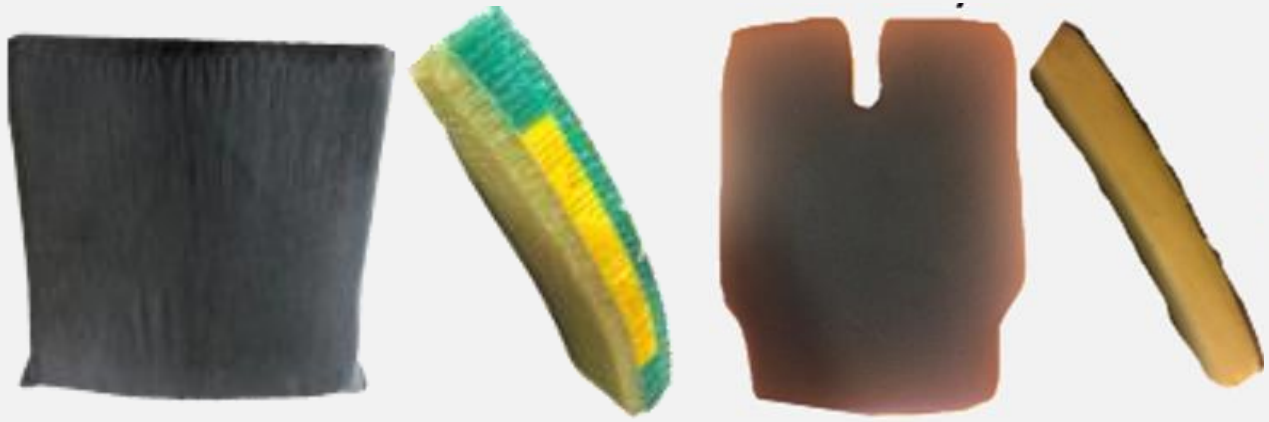
Figuur 3. De rolstoel

STUDIE OPZET

- 20 gezonde proefpersonen
- Parameters:
  - 2 rugleuninghoeken (45º & 60º)
  - 3 intensiteiten (1 statische en 2 dynamische)
  - 2 kussens (rolstoel & handbike)



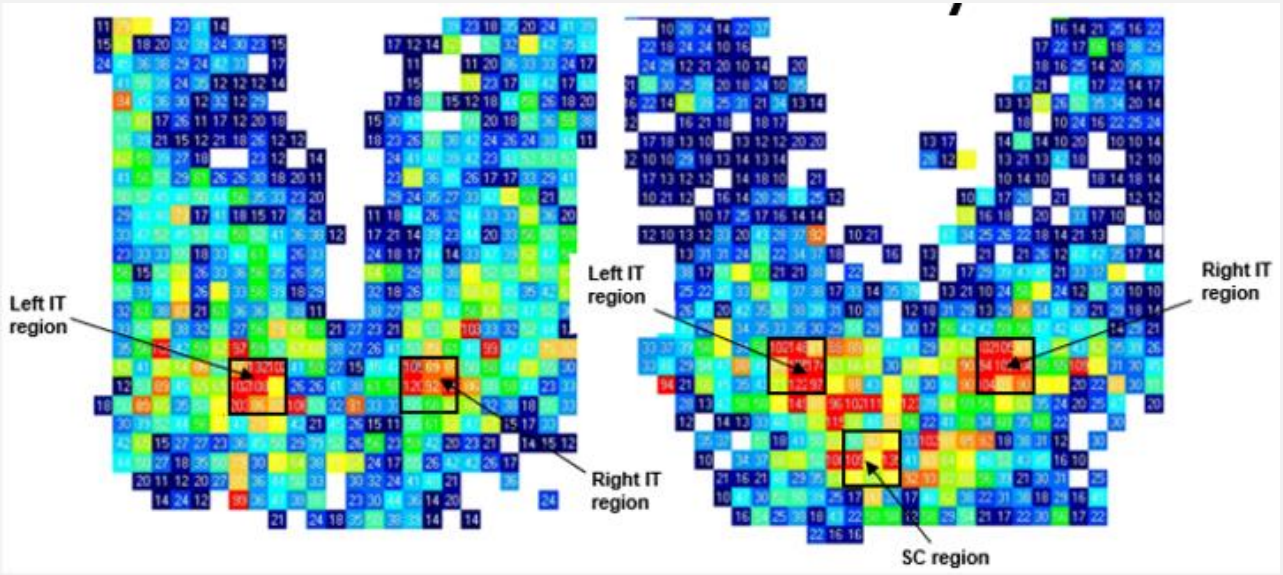
Figuur 4. De rugleuninghoek van 60º (links) en van 45º (rechts)



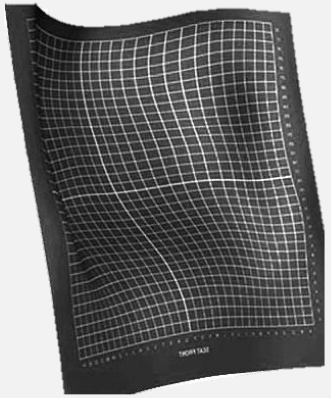
Figuur 5. Het rolstoelkussen (links) en het handbikekussen (rechts)

DATA VERZAMELING

- CONFORMat 5330E
  - Visueel lokaliseren van de botpunten (IT & SC)
  - 3x3 sensor gebied
- Twee uitkomstmaten
  - Peak pressure index (PPI) → drukkracht
  - Peak Pressure Gradient (PPG) → schuifkracht



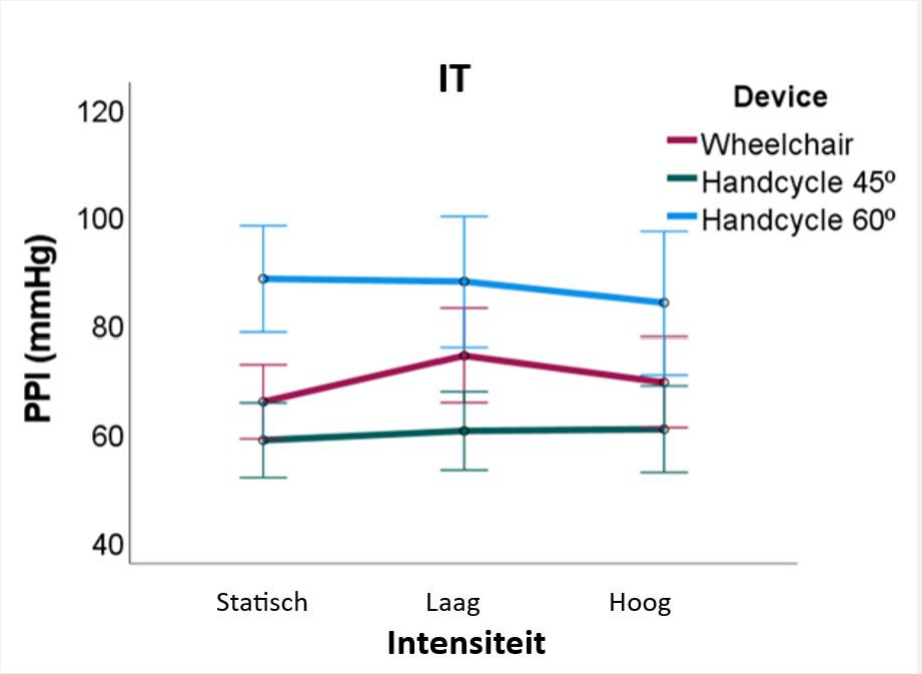
Figuur 6. De zitdruk in een rolstoel (links) en handbike (rechts)

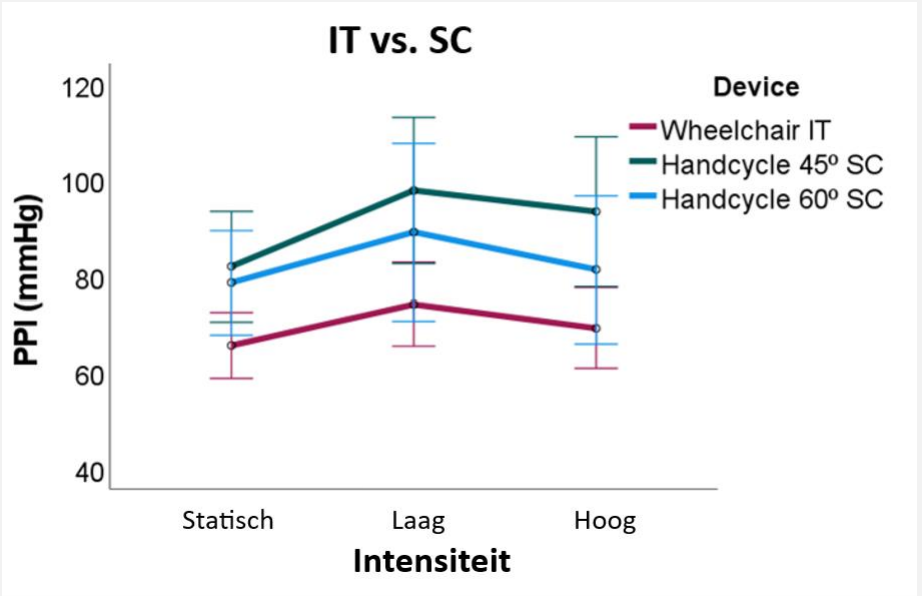


Figuur 7. De CONFORMat 5330E

RESULTATEN ZITDRUK (1)

- Rolstoel vs. handbike
  - IT: hoger in handbike 60º dan in de rolstoel (p=0.038)
  - IT vs. SC: hoger in de 45º handbike (p=0.005)
- Rugleuninghoek handbike
  - IT: lager bij een hoek van 45º (p<0.001)
  - SC: lijkt hoger bij een hoek van 45º (p=0.052)

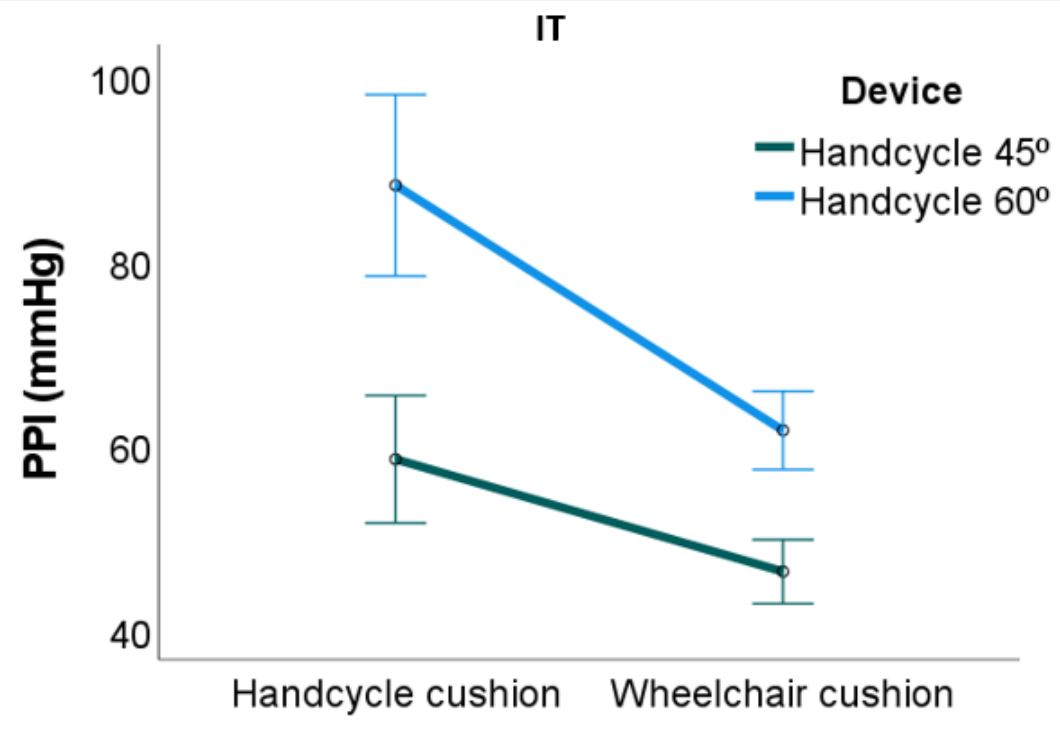


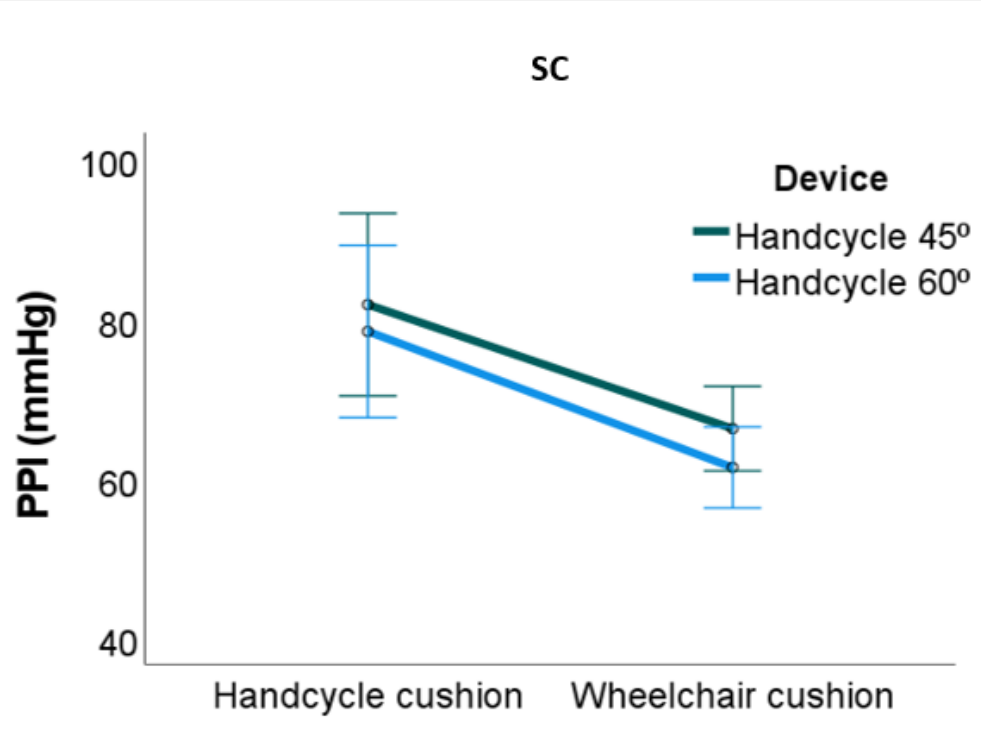


Figuur 8. De zitdruk (PPI) resultaten

RESULTATEN ZITDRUK (2)

- Kussen
  - IT: lager met het rolstoelkussen (p<0.001)
  - SC: lager met het rolstoelkussen (p=0.001)

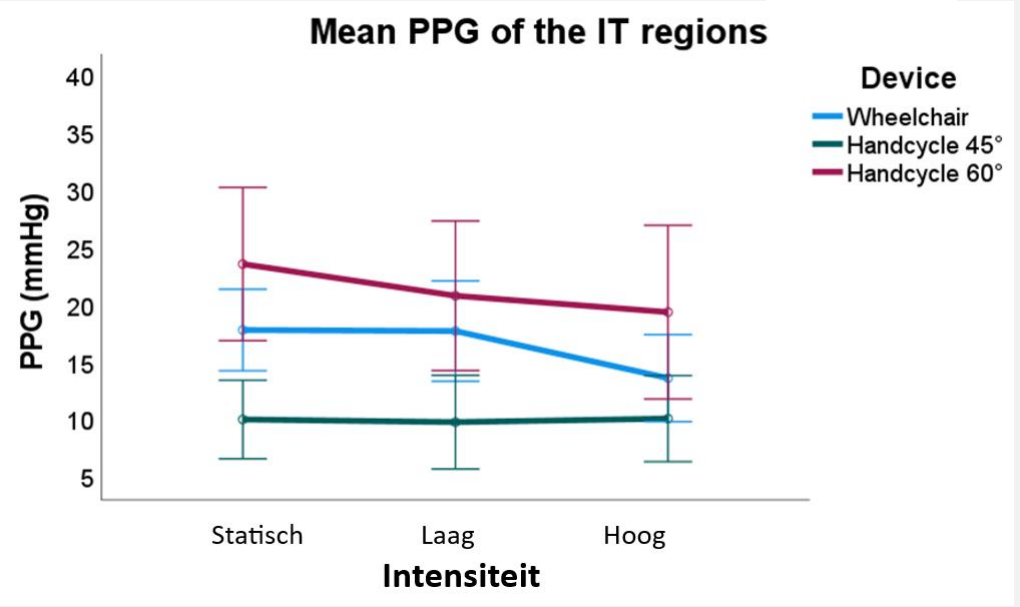


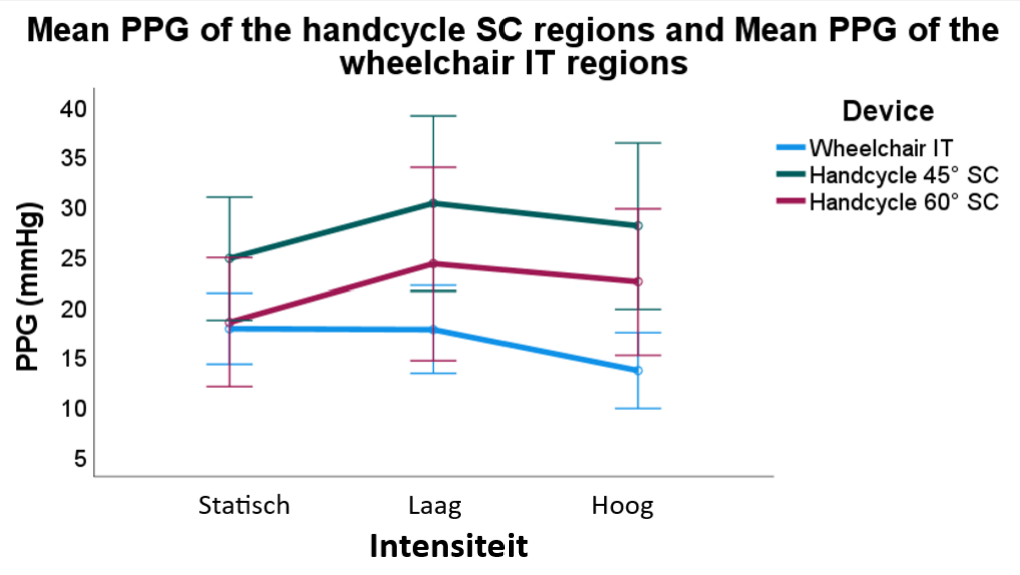


Figuur 9. De zitdruk (PPI) resultaten voor de twee kussens

RESULTATEN SCHUIFKRACHT (1)

- Rolstoel vs. handbike
  - IT: hoger in de rolstoel dan in 45º handbike ($p = 0.04$)
  - IT vs SC: hoger in de 45º handbike ($p < 0.01$)
- Rugleuninghoek handbike
  - IT: lager bij de 45º hoek ($p < 0.01$)
  - SC: Lijkt hoger bij de 45º hoek ($p = 0.05$)

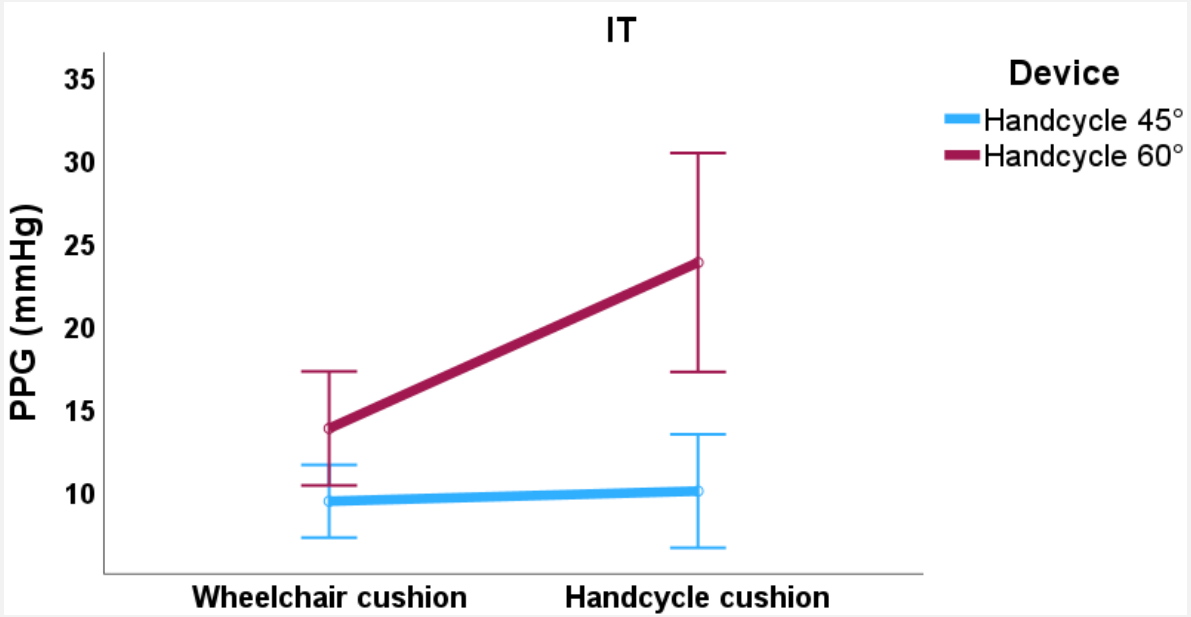


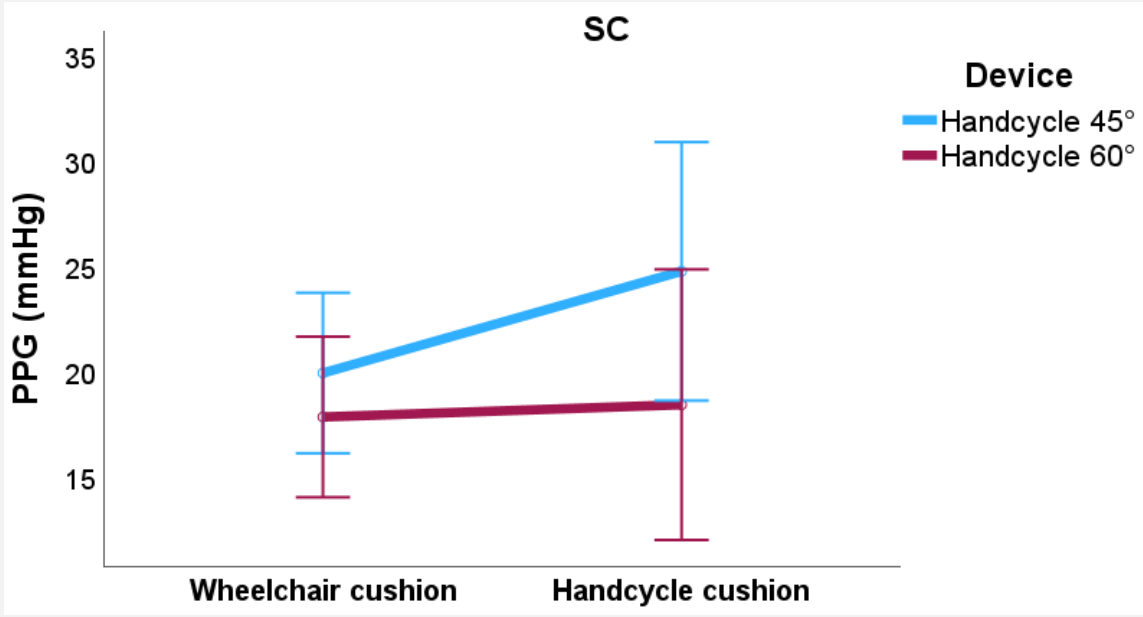


Figuur 10. De schuifkracht (PPG) resultaten

RESULTATEN SCHUIFKRACHT (2)

- Kussen
  - IT: lager met het rolstoelkussen ($p < 0.01$)
  - SC: geen significant verschil



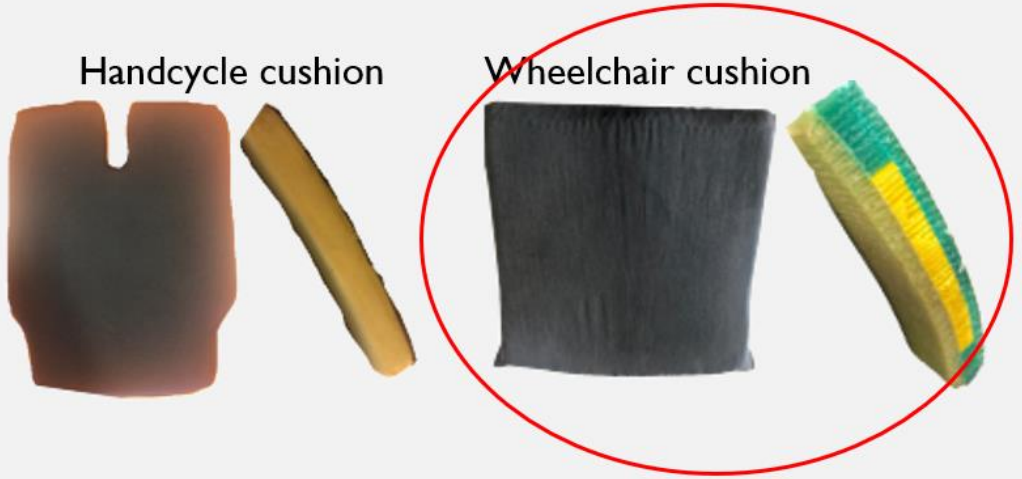


Figuur 11. De schuifkracht (PPG) resultaten voor de twee kussens

PRAKTISCHE RELEVANTIE

- Rolstoel vs handbike
  - IT vs SC: druk- en schuifkrachten hoger in handbike dan rolstoel
  - Conclusie: handbike risicovoller dan rolstoel
- Rugleuninghoek handbike
  - 60º → 45º: IT ↓, SC ↑
  - Conclusie: rugleuninghoek van 45º (maar let op SC!)
- Kussen
  - Druk- en schuifkrachten lager met rolstoelkussen
  - Conclusie: aangepast (rolstoel)kussen in handbike

Figuur 12. De aanbevolen rugleuninghoek van 45º (rechts)



Figuur 13. Het aanbevolen rolstoelkussen (rechts)

VRAGEN

LITERATUURLIJST

1. Shiferaw, W. S., Akalu, T. Y., Mulugeta, H., & Aynalem, Y. A. (2020). The global burden of pressure ulcers among patients with spinal cord injury: a systematic review and meta-analysis. *BMC Musculoskelet Disord*, *21*(1), 334. https://doi.org/10.1186/s12891-020-03369-0
2. Iyun, A. O., Malomo, A. O., Oluwatosin, O. M., Ademola, S. A., & Shokunbi, M. T. (2012). Pattern of presentation of pressure ulcers in traumatic spinal cord injured patients in University College Hospital, Ibadan. *Int Wound J*, *9*(2), 206-213. https://doi.org/10.1111/j.1742-481X.2011.00877.x
3. Chen, Y., Wang, J., Lung, C. W., Yang, T. D., Crane, B. A., & Jan, Y. K. (2014). Effect of tilt and recline on ischial and coccygeal interface pressures in people with spinal cord injury. *Am J Phys Med Rehabil*, *93*(12), 1019-1030. https://doi.org/10.1097/phm.0000000000000225
4. Andreoni, G., Pedotti, A., Ferrarin, M. (2001). Pressure distribution on Rolstoel cushions in Statisch sitting and during manual propulsion. *J Mech Med Biol*, *1*(1), 33-44.
5. Tam, E. W., Mak, A. F., Lam, W. N., Evans, J. H., & Chow, Y. Y. (2003). Pelvic movement and interface pressure distribution during manual Rolstoel propulsion. *Arch Phys Med Rehabil*, *84*(10), 1466-1472. https://doi.org/10.1016/s0003-9993(03)00269-7
6. Anderson, T. M., McKirgan, K. L., & Hastings, J. D. (2018). Seated pressures in daily Rolstoel and sports equipment: investigating the protective effects of cushioned shorts. *Spinal Cord Ser Cases*, *4*, 47. https://doi.org/10.1038/s41394-018-0084-5
7. Darrah, S. D., Dicianno, B. E., Berthold, J., McCoy, A., Haas, M., & Cooper, R. A. (2016). Measuring Statisch seated pressure distributions and risk for skin pressure ulceration in ice sledge hockey players. *Disabil Rehabil Assist Technol*, *11*(3), 241-246. https://doi.org/10.3109/17483107.2014.921939
8. Crane, B., Wininger, M., & Call, E. (2016). Orthotic-Style Off-Loading Rolstoel Seat Cushion Reduces Interface Pressure Under Ischial Tuberosities and Sacrococcygeal Regions. *Arch Phys Med Rehabil*, *97*(11), 1872-1879. https://doi.org/10.1016/j.apmr.2016.04.004
9. Damiao, J., & Gentry, T. (2022). A systematic review of the effectiveness of pressure relieving cushions in reducing pressure injury. *Assist Technol*, 1-5. https://doi.org/10.1080/10400435.2021.2010148
10. Indemedical. (2023). *Stimulite classic Rolstoel cushion*. Indemedical.com. Retrieved 19-01-2023 from https://www.indemedical.com/stimulite-classic-Rolstoel-cushion.html
11. Breukelen Van, M. D. (n.d.). *Arm-Power versus Arm-Trunk-Power, An Ergonomic Classification of Handbikes* https://docplayer.net/47945314-Arm-power-versus-arm-trunk-power-an-ergonomic-classification-of-handbikes-kees-van-breukelen-m-d.html
12. Katzmarzyk, P. T., Powell, K. E., Jakicic, J. M., Troiano, R. P., Piercy, K., & Tennant, B. (2019). Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee. *Med Sci Sports Exerc*, *51*(6), 1227-1241.
13. Kernozek, T. W., & Lewin, J. E. (1998). Seat interface pressures of individuals with paraplegia: influence of dynamic Rolstoel locomotion compared with Statisch seated measurements. *Arch Phys Med Rehabil*, *79*(3), 313-316. https://doi.org/10.1016/s0003-9993(98)90012-0
14. Heyward, O. W., Vegter, R. J. K., de Groot, S., & van der Woude, L. H. V. (2017). Shoulder complaints in Rolstoel athletes: A systematic review. *PloS one*, *12*(11), e0188410. https://doi.org/10.1371/journal.pone.0188410

DISCUSSIE PPI

- Backrest angle 45°: PPI IT 34%↓, PPI SC 10%↑
  - Reduction also seen in Rolstoels, no increase[3]
- Rolstoel vs. Handbike: higher in Handbike 60°
  - Contradiction to hypothesis
  - Rolstoel cushion lower PPI, bigger effect for 60°
    - In line with previous literature[89]
- Cushion
  - No/less immersion and off-loading

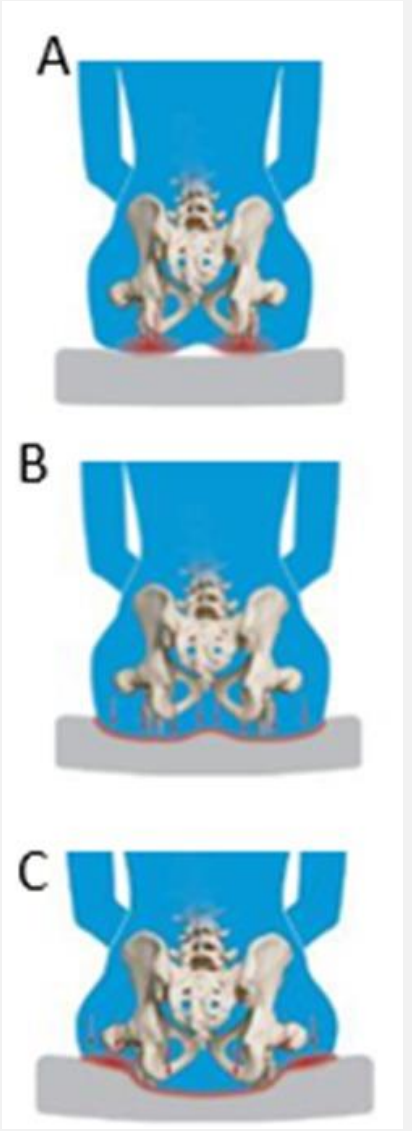


Figure 4: without (A), immersion (B), off-loading (C)

DISCUSSION – INTENSITY

- No effect on IT:
  - Peak pressure regions move away from bony prominences[5]
  - Tracked the IT: lower PPI during propulsion[45]
- Effect on SC:
  - Higher PPI for VT1 than Statisch: slanted backwards direction of pull phase → push into the Handbike → PPI ↑[11]
    - No exercise: risk of health issues[12]
    - Exercise: circulatory and lymphatic activity of the seated area[13]
  - Higher PPI for VT1 than VT2:
    - Forward lean of trunk with each push[11]
    - Higher intensity: chance of overuse injuries[14]

PROTOCOL

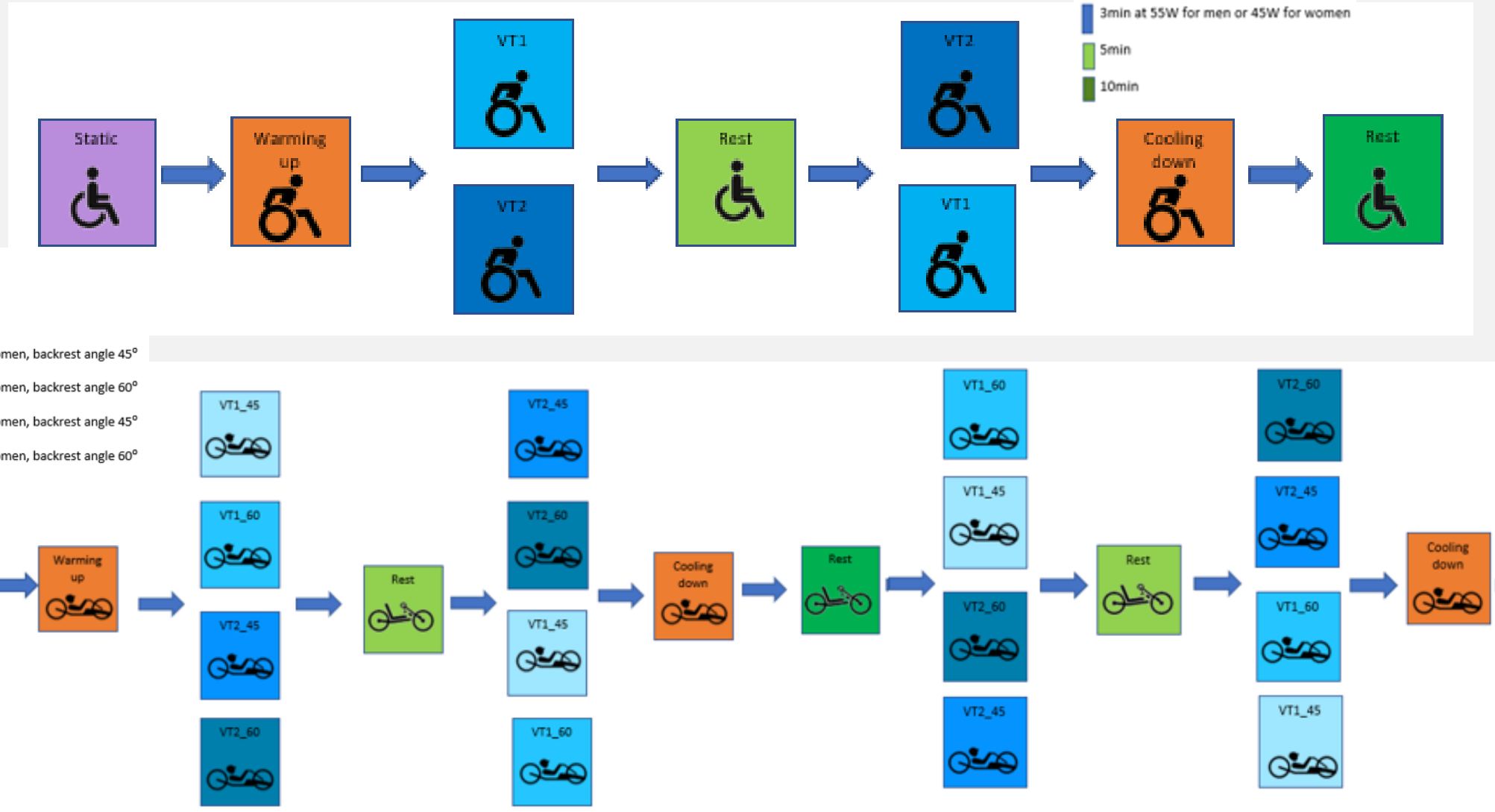


Figure 4: experimental protocol of the Rolstoel (top) and Handbike (bottom)

DETERMINING VT1 AND VT2

- VT1: 65% of peak heart rate (200-age)
  - Upper body exercises
- VT2: 80% of peak heart rate
- Pilot experiments and previous literature
- Constant speed: 60rpm, 1.11m/s

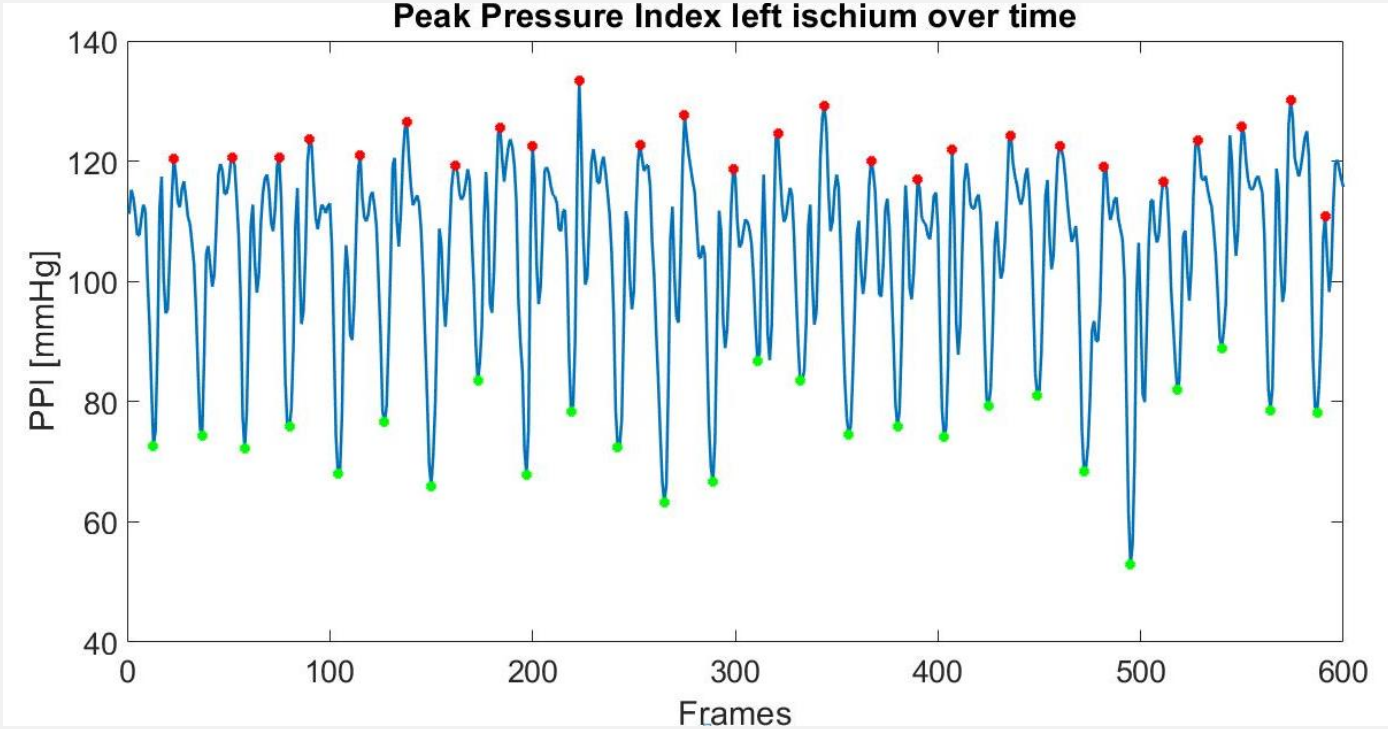
Figuur 8. De berekening van de PPG

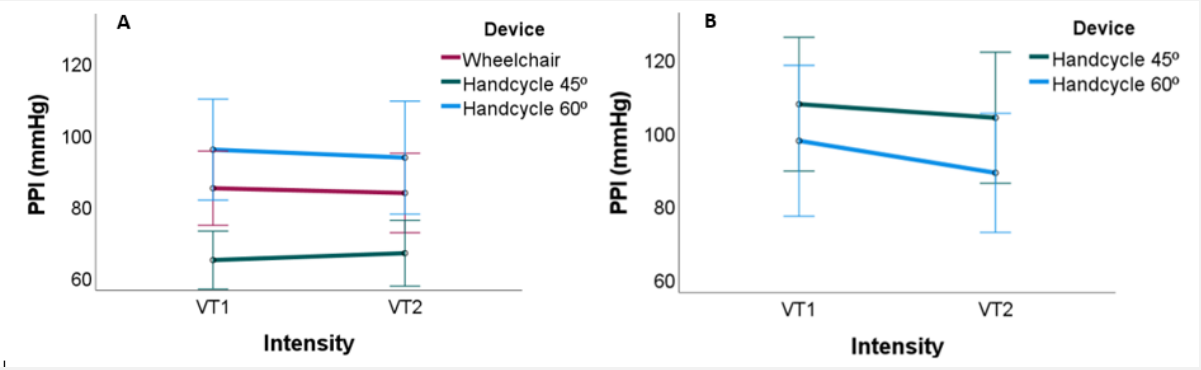
PPI

	Peak Pressure index (mmHg) Mean ±SD											Results										
	Wheelchair			Handcycle								Effect device				Effect intensity				Effect device * intensity	Effect cushion	Effect cushion * device
				45 degrees				60 degrees					Wheel-chair vs. H_45	Wheel-chair vs. H_60	H_45 vs. H_60		Static vs. VT1	Static vs. VT2	VT1 vs. VT2			
	Static_WC	VT1	VT 2	Static_WC	Static_HC	VT1	VT2	Static_WC	Static_HC	VT1	VT2	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*
PPI IT (mmHg)																						
Mean	66 ±15	74±19	69 ±18	46 ±7	58 ±15	60 ±16	60 ±17	62 ±9	89 ±21	88 ±26	84 ±28	**<0.001**	0.155	**0.038**	**<0.001**	0.299	0.360	1.000	0.251	0.262	**<0.001**	**0.001**
Max	NA	85±22	83 ±24	NA	NA	65 ±17	67 ±20	NA	NA	96 ±30	92 ±31	**0.004**	**0.027**	0.790	**<0.001**	0.780	NA	NA	0.780	0.559	NA	NA
Mean vs. max	66 ±15	85±22	83 ±24	NA	58 ±15	65 ±17	67 ±20	NA	89 ±21	96 ±30	92 ±31	NA	NA	NA	NA	**0.002**	**<0.001**	**0.029**	NA	NA	NA	NA
Min	NA	61 ±14	52 ±13	NA	NA	56 ±14	55 ±15	NA	NA	80 ±22	74 ±22	**<0.001**	1.000	**0.006**	**<0.001**	**0.001**	NA	NA	**0.001**	0.075	NA	NA
Mean vs. min	66 ±15	61 ±14	52 ±13	NA	58 ±15	56 ±14	55 ±15	NA	89 ±21	80 ±22	74 ±22	NA	NA	NA	NA	**0.001**	**0.037**	**0.003**	NA	NA	NA	NA
PPI SC (mmHg)																						
Mean	NA	NA	NA	66 ±11	82 ±25	98 ±33	93 ±33	61 ±11	78 ±23	89 ±39	81 ±33	0.052	NA	NA	0.052	**0.014**	**0.026**	0.343	**0.034**	0.368	**0.001**	0.788
Max	NA	NA	NA	NA	NA	107 ±39	104 ±38	NA	NA	97 ±44	89 ±35	**0.047**	NA	NA	**0.047**	**0.027**	NA	NA	**0.027**	0.318	NA	NA
Mean vs. max	NA	NA	NA	NA	82 ±25	107 ±39	104 ±38	NA	78 ±23	97 ±44	89 ±35	NA	NA	NA	NA	**<0.001**	**0.002**	**0.008**	NA	NA	NA	NA
Min	NA	NA	NA	NA	NA	88 ±27	83 ±30	NA	NA	81 ±36	73 ±32	0.061	NA	NA	0.061	**0.006**	NA	NA	**0.006**	0.510	NA	NA
Mean vs. min	NA	NA	NA	NA	82 ±25	88 ±27	83 ±30	NA	78 ±23	81 ±36	73 ±32	NA	NA	NA	NA	0.175	0.790	1.000	NA	NA	NA	NA
PPI IT vs SC (mmHg)																						
Mean	66 ±15	74±19	69 ±18	66 ±11	82 ±25	98 ±33	93 ±33	61 ±11	78 ±23	89 ±39	81 ±33	**0.001**	**0.005**	0.108	NA	NA	NA	NA	NA	NA	NA	NA
Max	NA	85±22	83 ±24	NA	NA	107 ±39	104 ±38	NA	NA	97 ±44	89 ±35	**0.018**	**0.020**	0.804	NA	NA	NA	NA	NA	NA	NA	NA
Min	NA	61 ±14	52 ±13	NA	NA	88 ±27	83 ±30	NA	NA	81 ±36	73 ±32	**<0.001**	**<0.001**	**0.021**	NA	NA	NA	NA	NA	NA	NA	NA

MAXIMA AND MINIMA

- PPI backrest angle: sign lower for Handbike 45º for the maximal and minimal IT pressure, and sign higher for the maximal SC pressure
- PPI intensity: lower PPI for VT2 than VT1 for maximal and minimal for IT and SC
- Mean vs. dynamic: minimal pressures lower, maximal pressures higher → pumping effect





VISUAL LOCALIZATION

- Two researchers independently determined locations based on heatmap CONFORMat, heatmap matlab, expected anatomical location
  - Between IT region boundaries: between 6 and 10 sensors
  - Distance between ITs is relatively constant within a participant
  - Locations within same device are relatively constant
  - SC region: rectangular area below the ITs