Postural-Change Detection Before and After Hemodialysis Using MediaPipe

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Biography

In 1987, he received a doctor of engineering from the Tokyo Institute of Technology for research on speeding up amorphous silicon thin film transistors.

From 1980 to 1987, he worked at Tokyo Institute of Technology as a research associate in the Department of Electronic and Physical Engineering, and from 1987 to 1990 as a research associate in the Faculty of Engineering, Takushoku University. 1990 to 1990, he worked at West Tokyo University of Science (now Teikyo University of Science) as an associate professor. 2007 to 2012, Department of Media Information Systems, Department of Life Sciences, he has worked as a professor.
Currently working on health status change detection using several kinds of sensors, video analysis and machine learning.

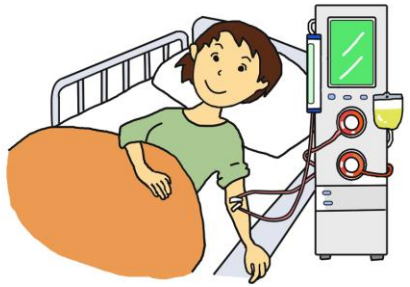
Topics of research interest of our group

Our research group is responsible for developing a health management system that integrates various sensing technologies. We collaborate with occupational therapists, physical therapists, and clinical engineers working in hospital settings. Specifically, we are advancing activity assessment from a rehabilitation perspective by leveraging digital technologies through medical-engineering collaboration.

Recently, we have begun applying the outcomes of our sensing technology research to the field of hemodialysis, where clinical engineers play a central role in patient care and device management.

Background – Hemodialysis and Fall Risk

•Hemodialysis = primary treatment for end-stage renal disease
•Post-dialysis symptoms: orthostatic hypotension, impaired balance → unsteadiness
•Falls in elderly dialysis patients → fractures, hospitalization, poor prognosis



Limitations of Conventional Assessments

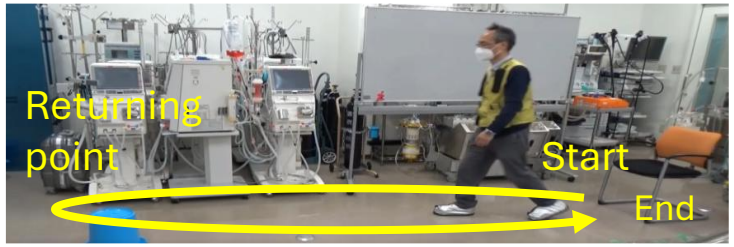
•Conventional balance tests (e.g., TUG test)
•Problems: subjective, low reproducibility, may miss subtle unsteadiness

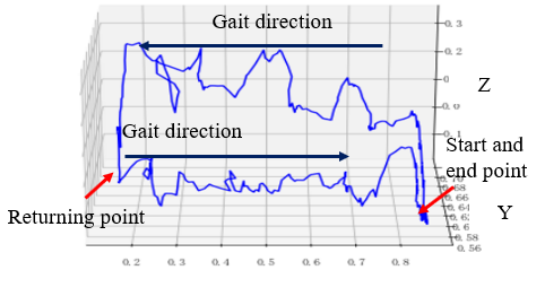
Our Previous Work

•Quantitative motion analysis using MediaPipe & MEMS sensors

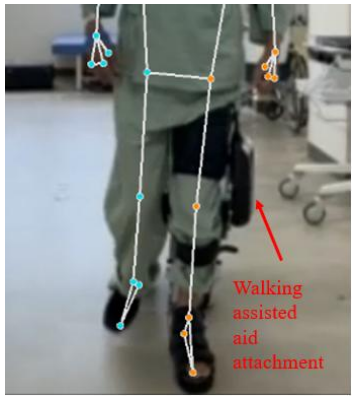
•Findings:

- Walking aids improved gait trajectory
- Pose estimation error analysis
- Hemiparesis gait changes
- Rehabilitation evaluation with digital

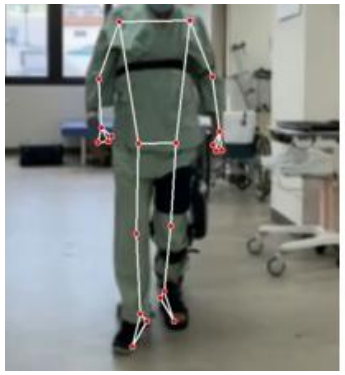




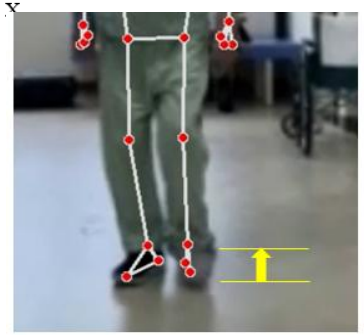
Y. Uchida et al, GLOBAL HEALTH 2023, pp. 12-17, IARIA.



Effect of walking-assisted aid attachment



Right shoulder dropping



The change in the final time of kicking the floor

Y. Uchida et al, International J. of Advances in Life science, vol.15, no 1&2, 2023, pp. 45-55 .

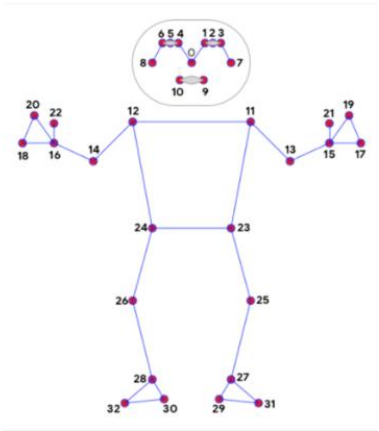
Study Concept

•Focus: Postural behaviour when stepping onto a **weighing scale** before/after dialysis

•Why? Small surface area → easier to detect subtle trunk sway, instability

•Tool: MediaPipe for pose estimation

weighing scale



G. Kaur, G. Jaju, D. Agawal, K. Lyer, and C. M. Prashanth, "Implementation of Geriatric Agility Detection Using MediaPipe Pose," International Journal of Recent Advances in Multidisciplinary Topics, vol. 3, 119, 2022, ISSN:2582-7839

Study Aim

- Develop a **quantitative method** for evaluating post-dialysis unsteadiness
- Approach:
  - Video-based pose estimation
  - Analysis of key body parts & motion patterns

Experiment

PARTICIANT INFORMATION.

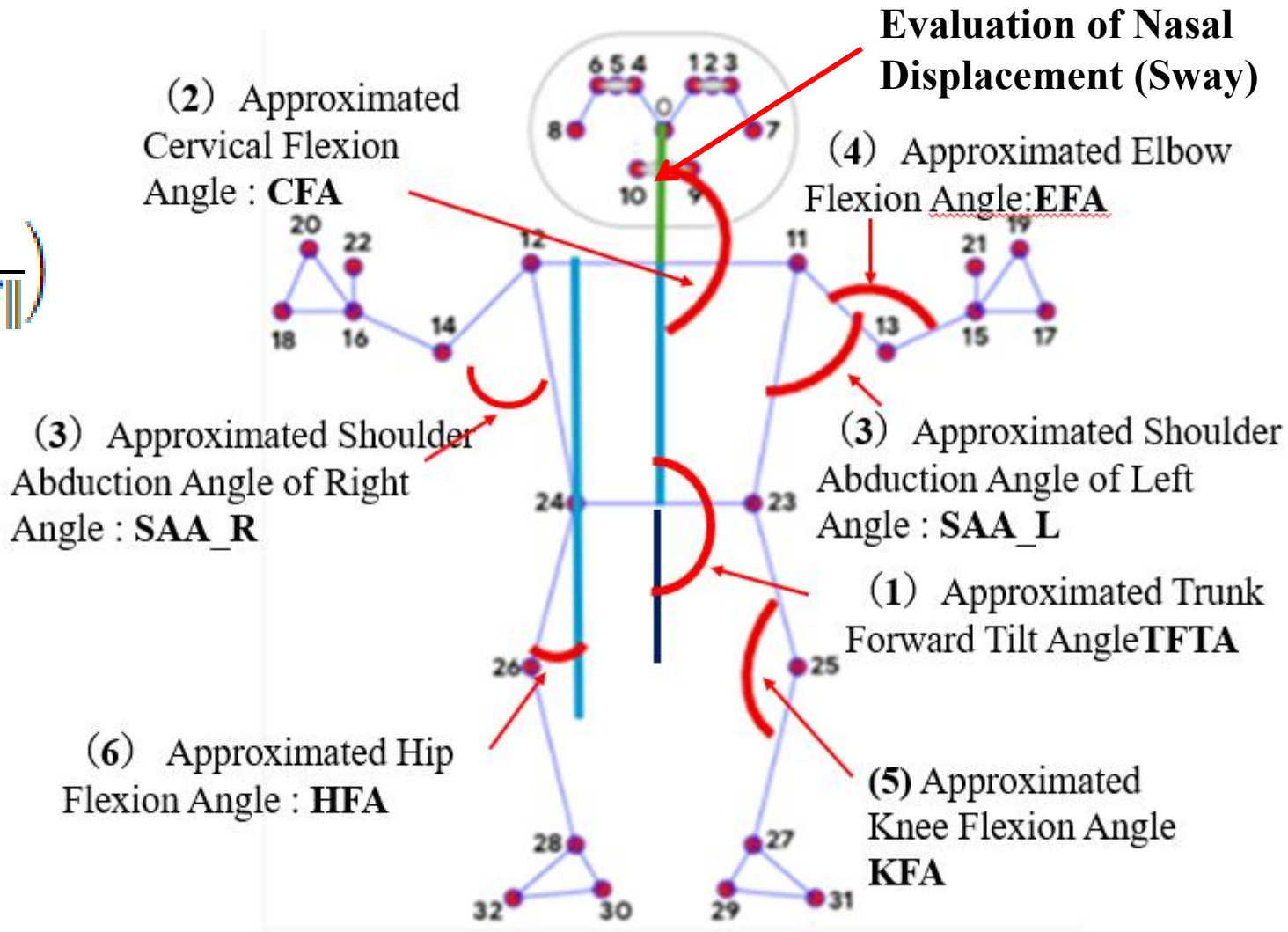
Subject	Age	Sex	Case of ESRD	ΔDW	ABI R	ABI L	Note
A	54	F	CG	4.2	1.10	1.17	BP reduced
B	62	M	Unknown	4.8	1.18	1.21	BP stable
C	78	M	DM	5.3	0.98	1.46	BP stable
D	51	M	DM	6.0	1.15	1.23	BP stable

ESRD: End Stage Renal Disease
ABI : Ankle-Brachial Index
ΔDW: change from the ideal Dry Weight
CG : Chronic Glomerulonephritis
DM : Diabetes Mellitus

The selection criteria for participants in this study were based on blood pressure fluctuations after dialysis, visual dizziness.

Postural Indices and Joint-Angle Computation

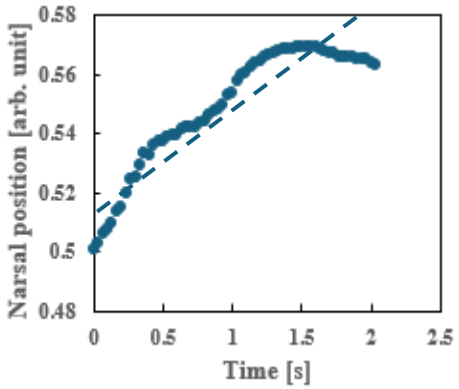
$$\theta = \cos^{-1}\left(\frac{\vec{A}\cdot\vec{B}}{\|\vec{A}\|\cdot\|\vec{B}\|}\right)$$



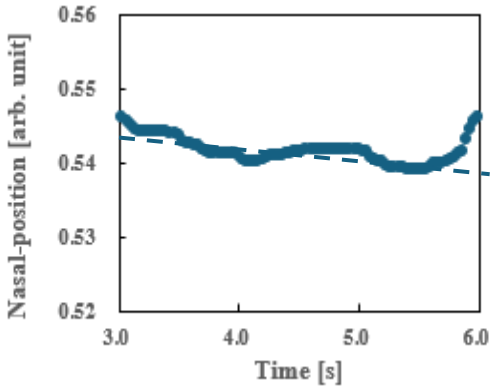
1. Evaluation of Nasal Displacement (Sway)

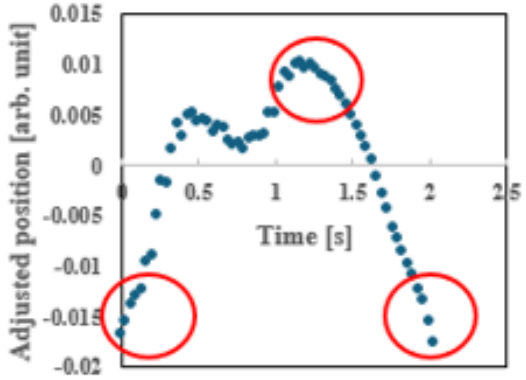
participant A

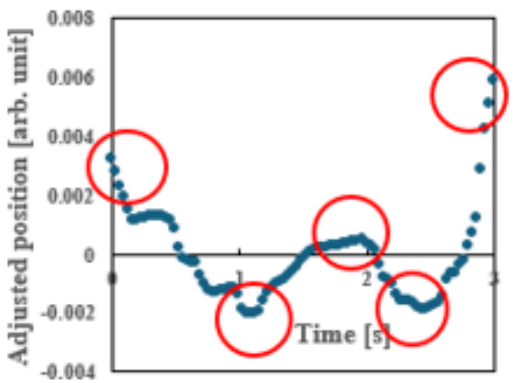
(1) Before



(2)After





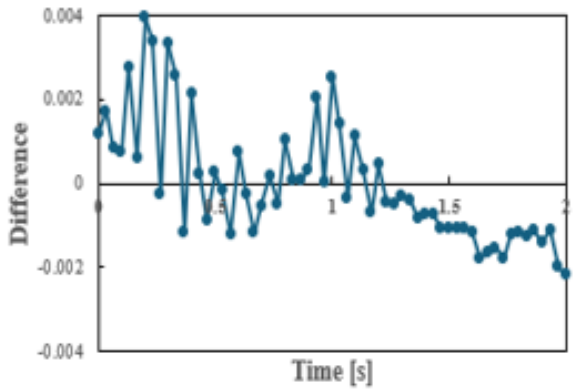


A linear correction to the x-axis nasal-position data, adjusting the overall mean to zero.

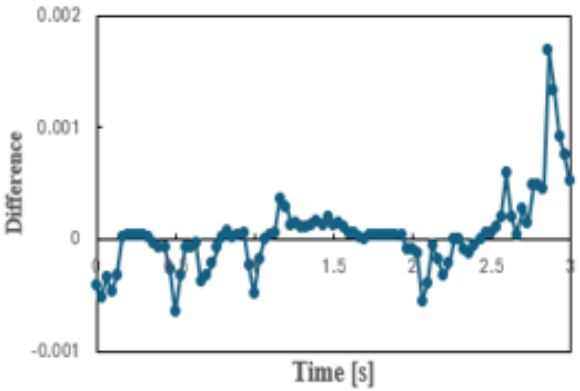
Numbers of transitions in the right and left directions

		Before	R-L	After	R-L
A	L	1	1	3	-1
	R	2		2	
B	L	1	1	2	0
	R	2		2	
C	L	2	1	3	0
	R	3		3	
D	L	1	1	2	1
	R	2		1	

Time-series differential analysis of the x-axis nasal position



(1)

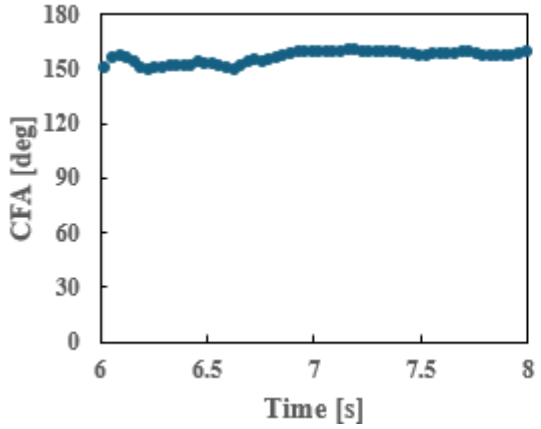


(2)

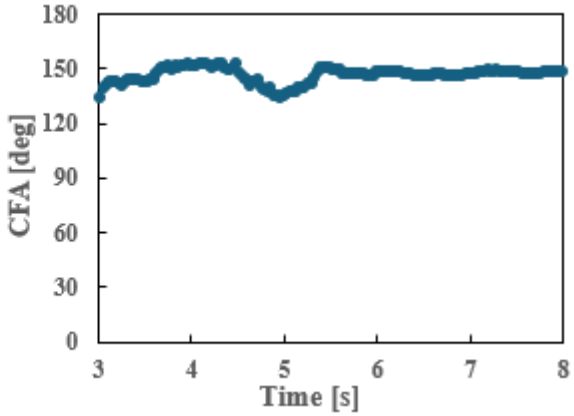
2. Approximated Trunk Forward Tilt Angle (TFTA) for Subject B

Before hemodialysis was 163°
After hemodialysis, it decreased significantly to 136 °

3. Approximated Cervical Flexion Angle (CFA) for Subject B

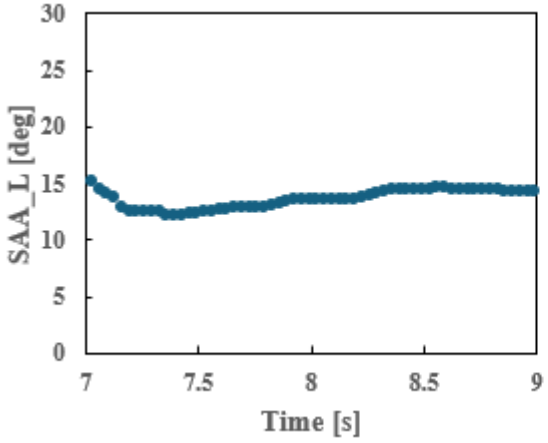


(1)

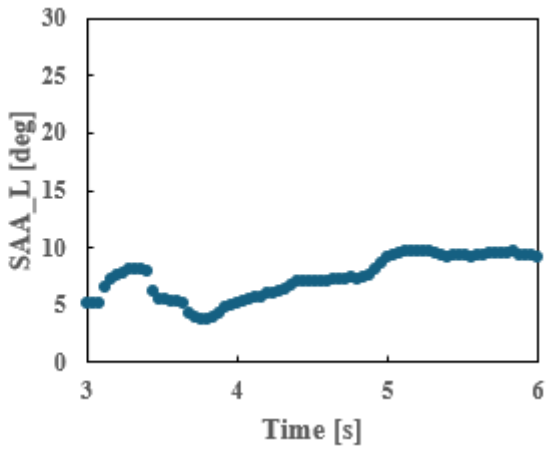


(2)

4. Approximated Shoulder Abduction Angle of Left and Right (SAA_L) for Subject A

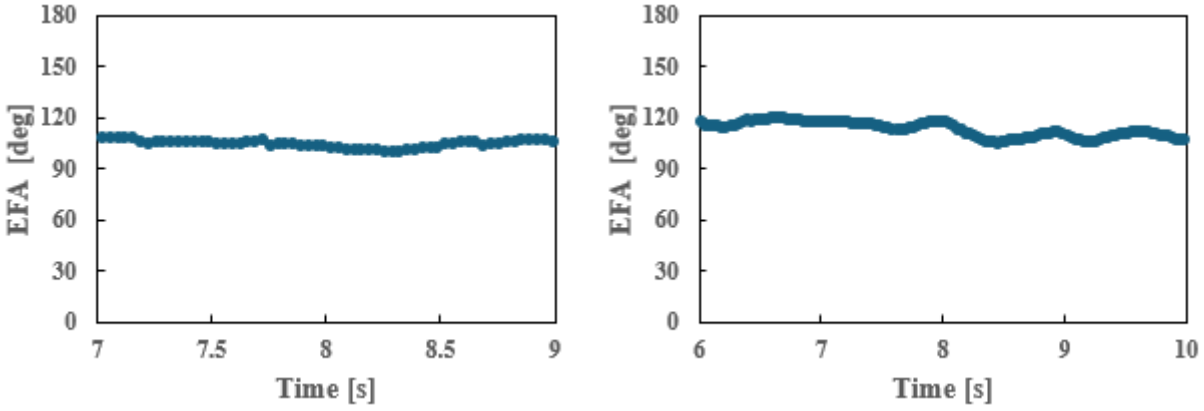


(1)



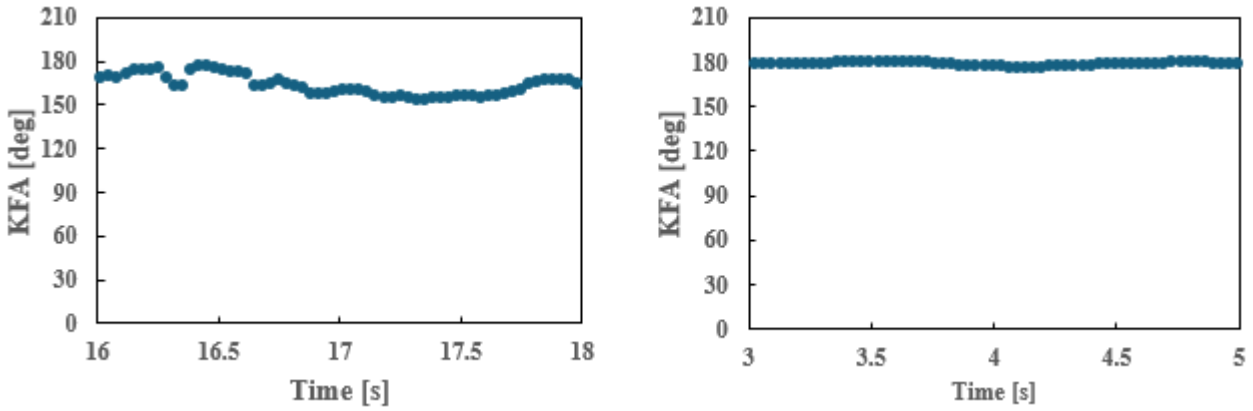
(2)

5. Approximated Left Elbow Flexion Angle (EFA) for Subject C



(1) (2)

6. Approximated Knee Flexion Angle (KFA) for subject D



(1) (2)

7. Approximated Hip Flexion Angle (HFA)

Because of the short recording duration and oblique camera positioning, the accuracy was limited. Nevertheless, directional changes in the flexion angle were observed in two participants, potentially reflecting the physiological changes caused by hemodialysis.

MEASURED VALUE FOR EACH EVALUATION ITEM.

		nose	TFTA	CFA	SAA_Left	SAA_Right	EFA	KFA
		Dif	deg	deg	deg	deg	deg	deg
A	BFR	6.50E-02	161	147	14.3	19.3	100	166
	AFT	7.70E-03	177	137	7.70	13.1	118	140
	Ratio	0.11	1.10	0.93	0.54	0.68	1.18	0.84
B	BFR	7.20E-02	163	163	18.0	9.60	120	160
	AFT	5.60E-02	136	146	13.3	14.7	112	161
	Ratio	0.78	0.83	0.90	0.74	1.53	0.93	1.00
C	BFR	2.60E-02	165	156	20.3	30.3	105	149
	AFT	3.20E-02	165	152	23.5	26.8	112	149
	Ratio	1.23	1.00	0.97	1.16	0.88	1.07	1.00
D	BFR	4.30E-02	152	151	24.8	30.6	116	167
	AFT	4.10E-02	154	142	22.1	14.7	124	180
	Ratio	0.95	1.01	0.94	0.89	0.48	1.07	1.08

EVALUATION RESULTS

		nose	TFTA	CFA	SAA_Left	SAA_Right	EFA	KFA
		Dif	deg	deg	deg	deg	deg	deg
A	Ratio ≧5% ○ ≧10% ◎	◎	◎	○	◎	◎	◎	◎
B		◎	◎	○	◎	◎	X	X
C		◎	X	X	◎	◎	X	X
D		○	X	○	◎	◎	X	○

Conclusion

- Evaluated **pre- and post-hemodialysis changes** using estimated joint angles (elbow, knee, hip).
- Comparative analysis showed **flexion angle variations** (increase/decrease) in some participants after hemodialysis.
- Findings suggest potential links between **angle changes and physical condition/postural instability**.
- **Limitations:** oblique camera placement, static assessment.
- **Future direction:** integration of **sensor-based measurements** and **dynamic assessments** for continuous evaluation.

ACKNOWLEDGMENT

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