ICAROS

Studies

ICAROS GmbH
Martinsried, Germany
2022

ICAROS REVOLUTIONIZES THE WAY PEOPLE EXERCISE AND PLAY

JANUARY 2016

Contents

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Introduction

PLANK POSITION & CORE ACTIVATION

The ICAROS Pro device is thought for an assisted, global core training, offering a wide range of training modalities keeping safety and effectiveness as main aim.
ICAROS enables users to train core and other body districts at the same time using the „plank position "(also known as „ bridge ") as base which is known to be one of the most important and effective exercises in core conditioning.
Short and long leverage plank, side plank, and some other classical core exercise, like the „bird-dog ", can be performed on ICAROS with several variation possibilities.
The adjustable structure enables the therapist or the trainer to find out the optimal set up for every case and allow the precise repeatability of the exercise.

Kneeling plank
on ICAROS Pro

Long leverage plank
on ICAROS Pro

Bird dog on ICAROS Pro

PLANK POSITION & CORE ACTIVATION

The difficulty level of the exercise can be selected regulating the range of motion and the reactivity level of the equipment, offering also the possibility to have a high performing unstable surface maintaining a very high safety standard. Enabling even subjects with a low training experience to execute this kind of exercises.

By many trials conducted in order to understand which type of plank is more effective, it was actually demonstrated that planking on an instable surface gives a greater core activation than a stabile plank. Furthermore the evidence shows also that the most effective core activation is given from those exercises where also other distal muscle groups are involved (e.g. shoulder). At our advice it´s to note that all the described core activating situation are obtained with exercise that require a good fitness and experience level when performed in the traditional way.

With ICAROS, it is possible to get all these effects in a safe, controlled and measurable way, so that the exercises are suitable also for subjects with conditions (e.g. Low Back Pain syndrome) as therapy (rehab), or in all core instability situations as prevention (prehab).

The machine structure allows to separate the movements on the sagittal and frontal planes as the combined sum of both them, granting a really high quality of the repeatability of the base motions and providing the optimal conditions for the motor learning and core strengthening process.

Many important details as the possibility to switch continually and with flow from a plank position (front) to another (side), or to check and regulate the scapulas position have a fundamental role in developing core stability with efficacy, precision and in global synergy with the whole body.

On ICAROS Pro, as we tested with a sEMG (a 4 channels device from OT BioLab measuring the extensor spinaes and the external obliques)) all these crucial points were confirmed. The maximal core muscle activation was registered during the transition between the front plank (or front bridge) and the side plank (or side bridge) position.
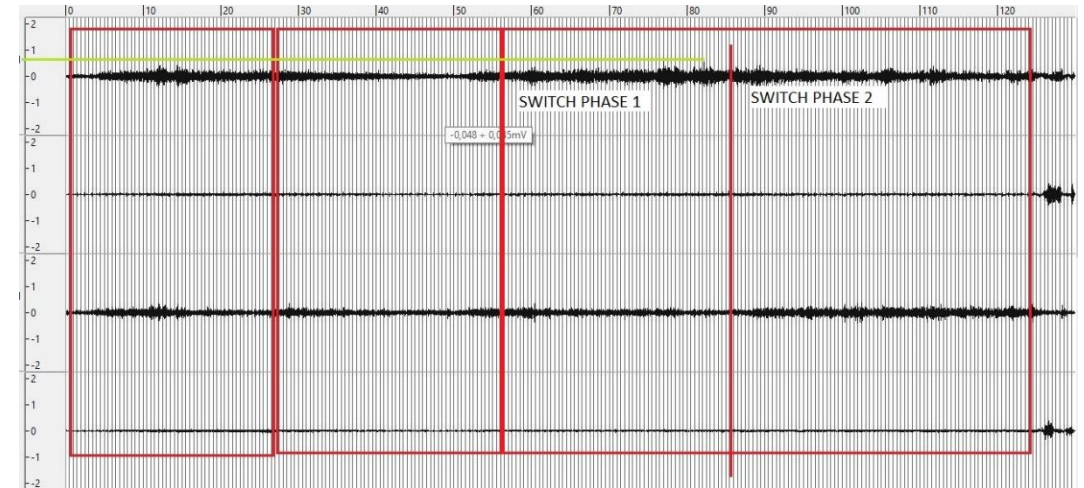
CORE TRAINING EFFECTS

In the last decades the role of the core in injury prevention and rehabilitation was supported by several trials and practice based evidence.
The effects of such a training are not only effective, in the spine and trunk districts, in decreasing pain and increasing active range of motion in patients with chronic low back pain [18], but it promotes and improves the global coordination and joints movement precision, and of course spinestability.

The effects of a three days training on ICAROS was tested internally, using the Corehab platform, a validated medical device on four subjects with different level of training and no injuries (age 27-51).
The global score is given by three different percentage scores:

- Precision (%): ability to reach the target angle at the exact moment.
- Stability (%): ability to maintain balance.
- Accuracy (%): ability to avoid compensations.

The internal pilot trial indicate that every subject improved his global coordination abilities.

Subject	Score Trial1 %	Score Trial2 %	Difference %	Mean %
De l	83	86	+3	
Da l	77	82	+5	
J l	85	93	+8	
J l	72	78	+6	
L l	80	82	+2	
M l	82	89	+7	
			31	5,166

Study I

"The influence of extra Icaros training in rehabilitation aftercare
on the daily limitations and trunk muscles strength
in patients with lumbar spinal problems "

conducted at Technical University of Munich, 2018
Sports Science Faculty

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Question:

"Does additional exercise with the Icaros have a positive effect on the subjective experience of daily limitations or strength parameters of the trunk muscles in patients with lumbar spinal problems?"

Procedure:

- 42 lumbar spinal problems patients in aftercare

- 26 at pre-test

- 12 appointments

- 20 at post test

Test Subjects:

Intervention group (n=9)
Control group (n=11)

Metholodogy- Test

Oswestry Disability Questionnaire (Osthus et al., 2006)

10 minute warm-up on the ergometer

Isokinetic reading:

5 times at 60°/s
15 times at 90°/s

Isometric reading:

60°, 45°, 30° flexion
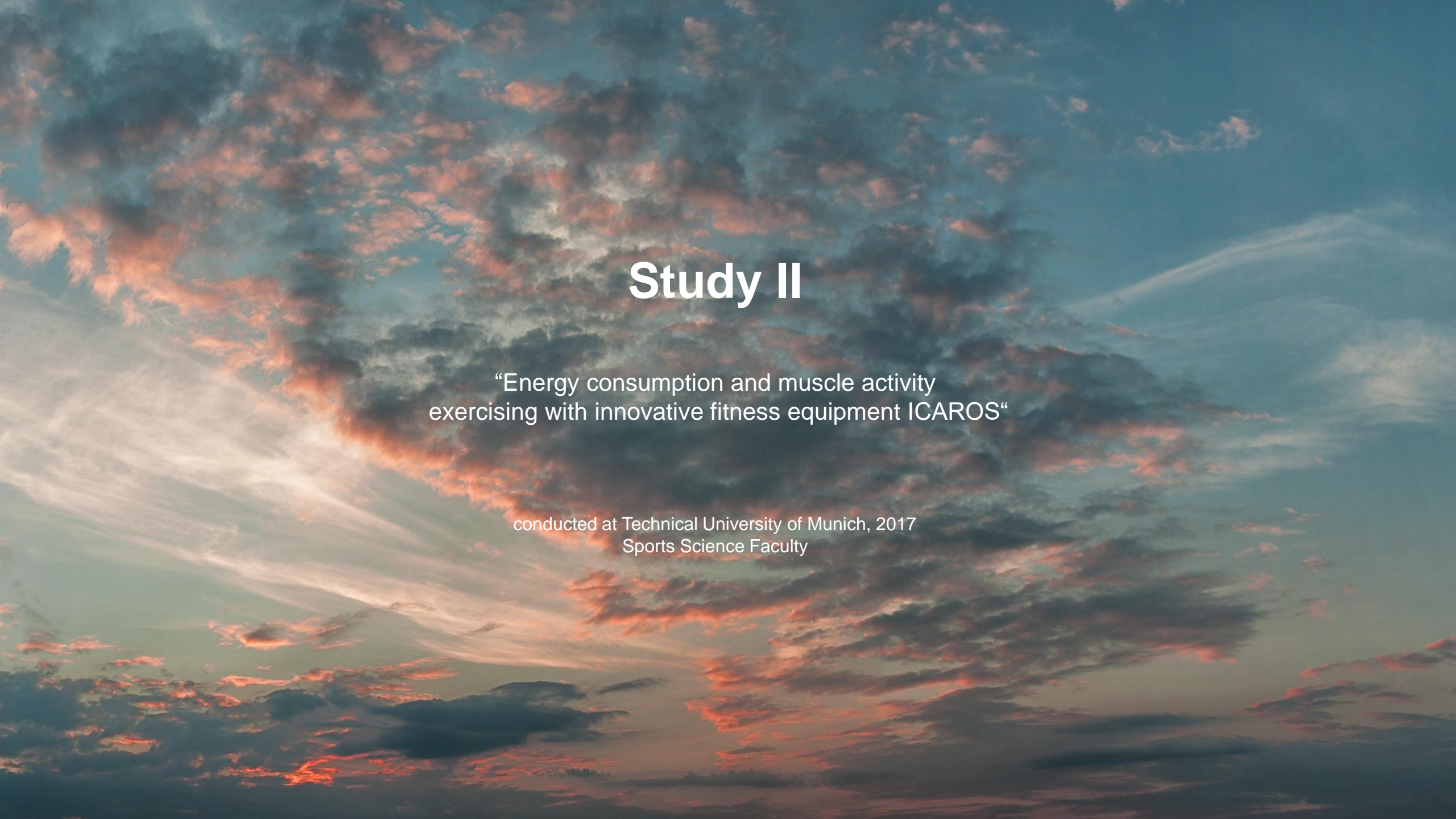Ratio of extensors : flexors

Study I

Results

- Isokinetic strength ratio not significantly improved Expectation of pain? (Al-Obaidi, 2000)

- **All other parameters improved** more than in the control group

- Isometric flexion at 60° and 45° **significantly more improved** than in the control group

- Isometric extension and strength ratio at 30° flexion **significantly more improved** than in the control group

- The **motivational nature** of ICAROS is positive for the continuation of sports activity after rehabilitation

- Usage also for shoulder problems or neurological disorders?

- Further studies are being conducted
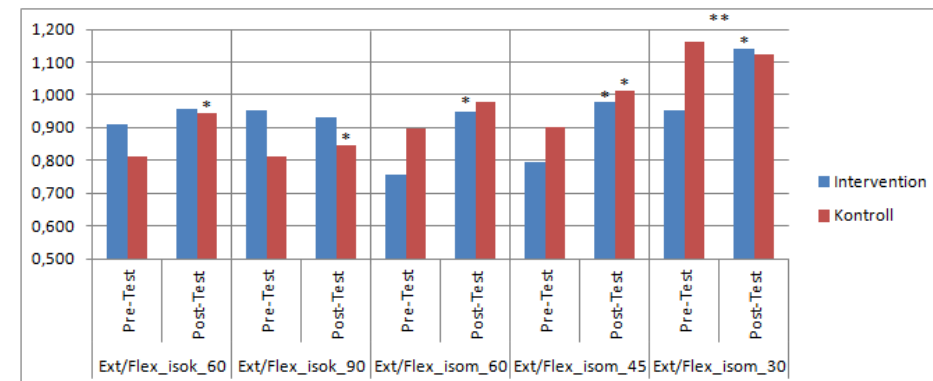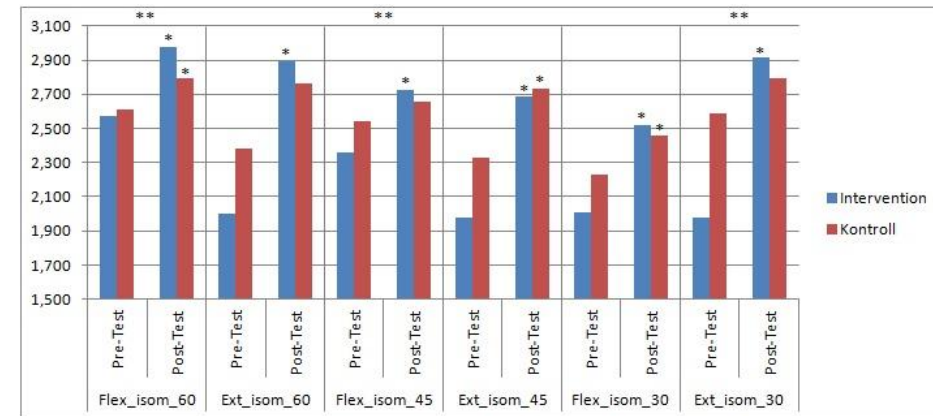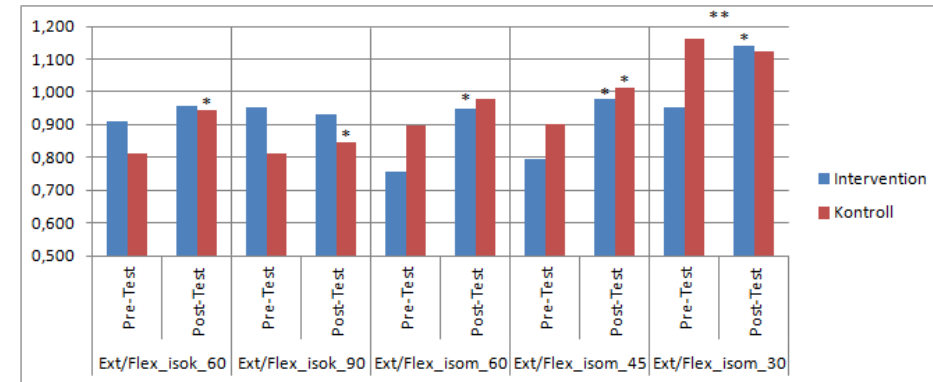
Study II

"Energy consumption and muscle activity
exercising with innovative fitness equipment ICAROS"

conducted at Technical University of Munich, 2017
Sports Science Faculty

Question 1:

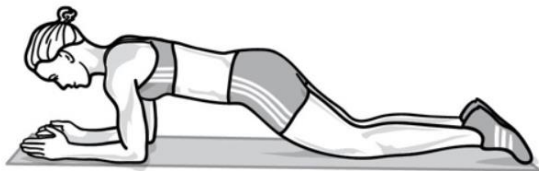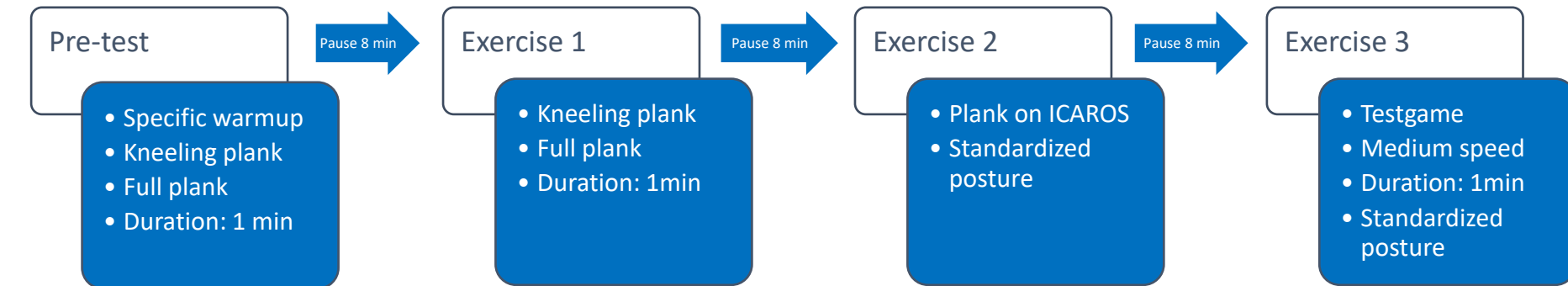"How high is the calorie consumption during exercising with ICAROS training?"

Question 2:

"How intense is the muscle activation during exercising with ICAROS training equipment?"

Study II

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Metholodogy:

| Pre-test		Exercise 1		Exercise 2		Exercise 3
• Specific warmup • Kneeling plank • Full plank • Duration: 1 min	**Pause 8 min →**	• Kneeling plank • Full plank • Duration: 1min	**Pause 8 min →**	• Plank on ICAROS • Standardized posture	**Pause 8 min →**	• Testgame • Medium speed • Duration: 1min • Standardized posture

Study II

ICAROS

Results

The muscle stimulation **doubled** compared to regular kneeling plank

Calorie consumption **increased by 30%** compared to regular kneeling plank
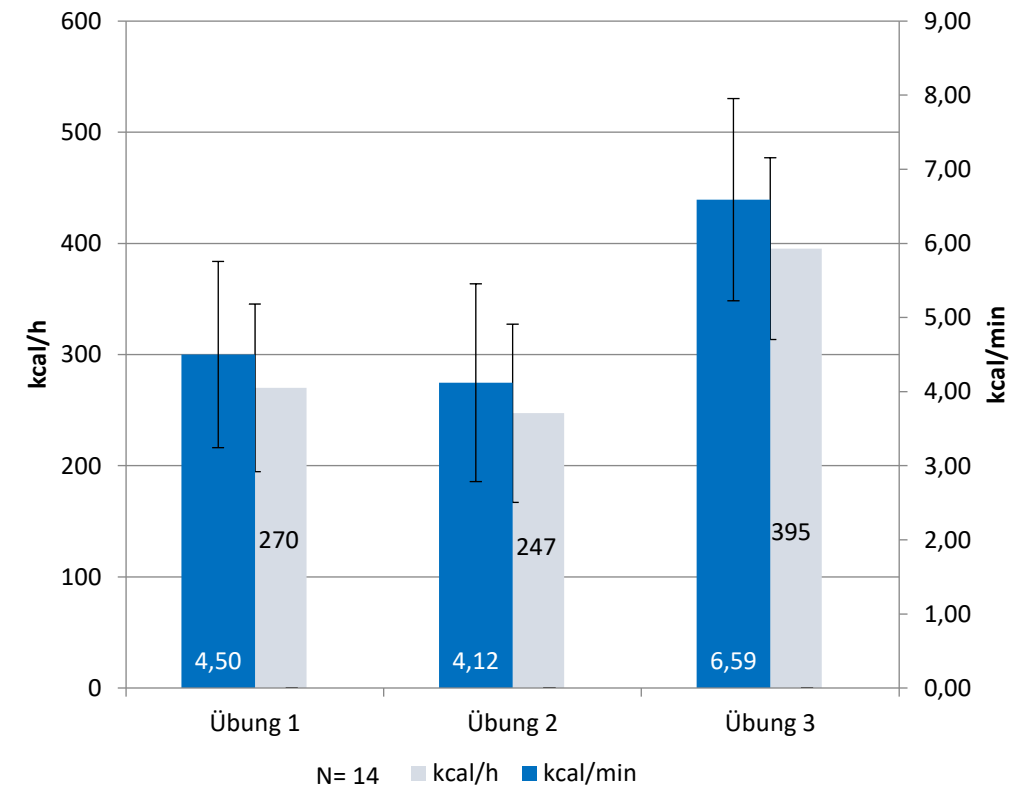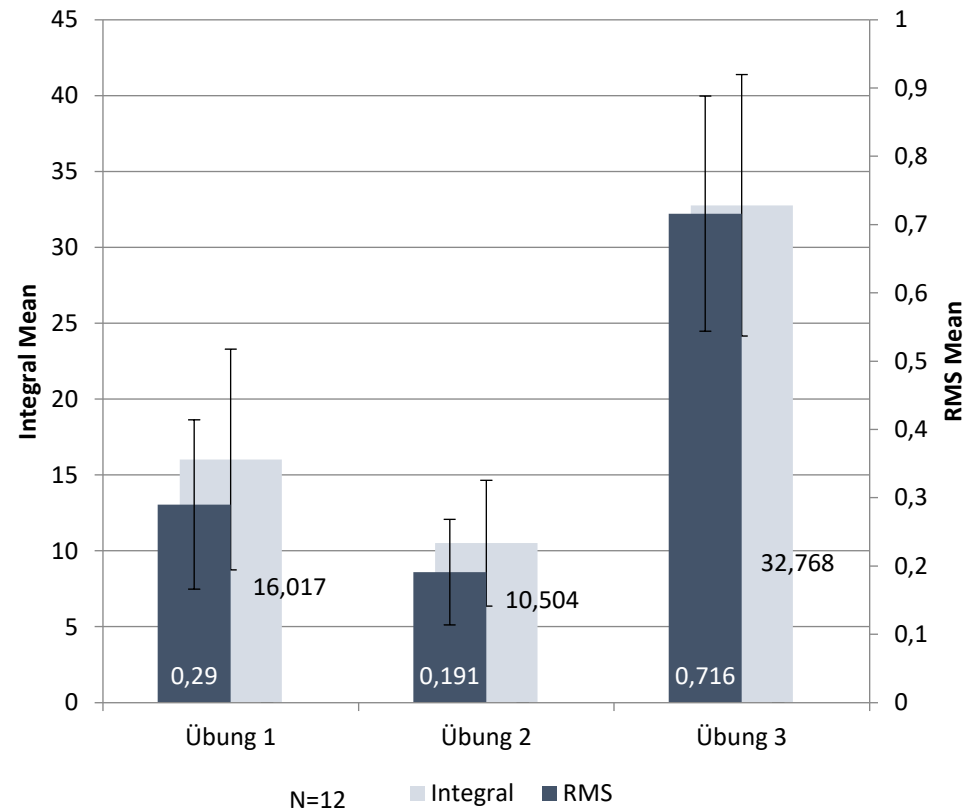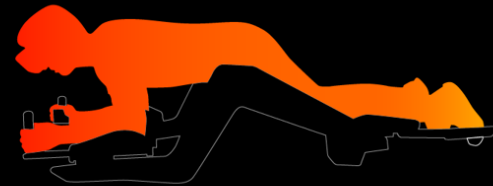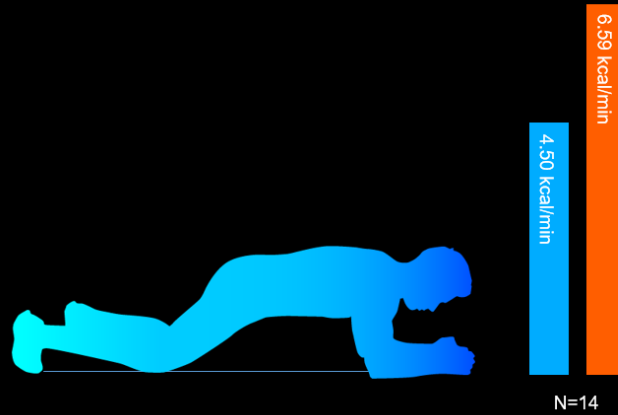
ICAROS Workout Efficacy
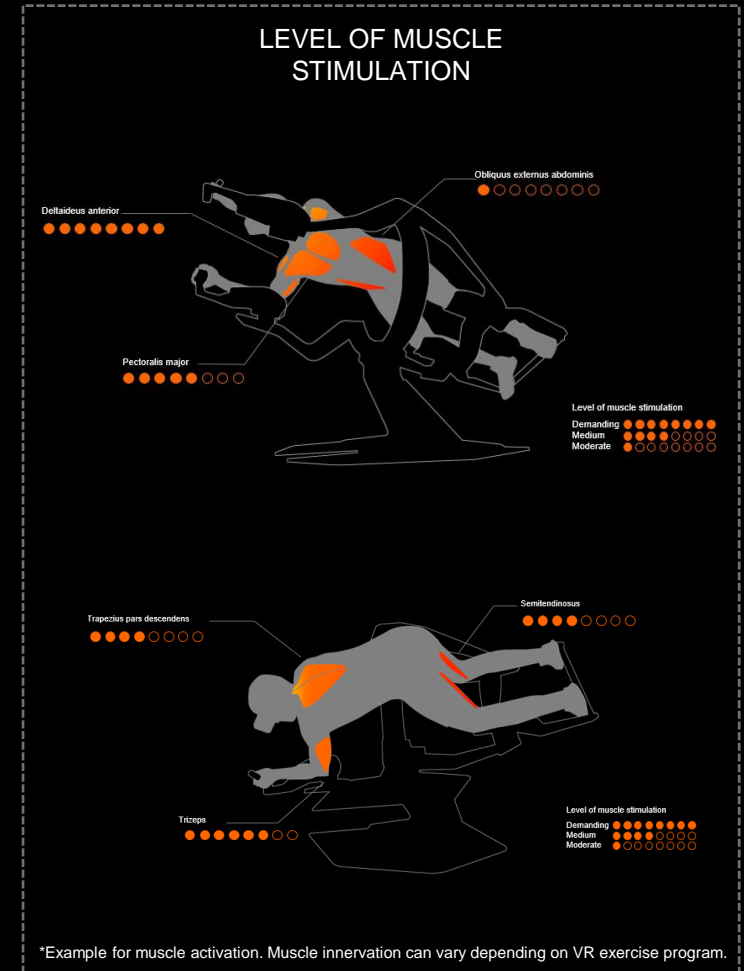
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Calorie consumption increased by

30%

compared to kneeling plank.

6.59 kcal/min

4.50 kcal/min

N=14

Muscle activation increased by

100%

compared to kneeling plank.

0.71 V [RMS]

0.29 V [RMS]

N=12

LEVEL OF MUSCLE STIMULATION

Obliquus externus abdominis ○○○○○○○○

Deltaideus anterior ●●●●●●●●

Pectoralis major ●●●●○○○○

Level of muscle stimulation
Demanding ●●●●●●●●
Medium ●●●●○○○○
Moderate ●○○○○○○○

Trapezius pars descendens ●●●○○○○○

Semitendinosus ●●●○○○○○

Trizeps ●●●●○○○○

Level of muscle stimulation
Demanding ●●●●●●●●
Medium ●●●●○○○○
Moderate ●○○○○○○○

*Example for muscle activation. Muscle innervation can vary depending on VR exercise program.

Study III

"Training 2.0? Full Body Exergaming in Virtual Reality"

Several studies conducted at German Sports University Cologne, 2016 - 2018

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https://www.youtube.com/watch?v=ODcs1JU2W9Q

Dr. Boris Feodoroff
DIGITAL HEALTH EXPERT
GERMAN SPORT UNIVERSITY COLOGNE

ICAROS VR - Training and Prevention in Virtual Reality

2.095 Aufrufe

ICAROS VR - Training and Prevention in Virtual Reality

2.095 Aufrufe

Study III

"Effects of Full Body Exergaming in Virtual Reality on Cardiovascular
and Muscular Parameters: Cross-Sectional Experiment"

conducted at the Institute of Movement Therapy and Movement-Oriented Prevention and Rehabilitation,
German Sport University Cologne, Cologne, Germany (2019)

Study Objectives:

The purpose of this study was to investigate the effect of a fully immersive virtual reality (VR)-based training system on cardiovascular and muscular parameters of young adults.

Subjects:

- 33 male participants (mean age 23.90 [SD 4.58] years)

- BMI <25 kg/m2

- Height between 170 and 190 cm

Methods:

A cross-sectional analysis of muscle activity (surface electromyography), heart rate, perceived rate of exhaustion (RPE), cybersickness symptoms, perceived workload, and physical activity enjoyment (PACES) in 33 participants performing two 5-minute flights on a new training device.

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Methodology - Test

Questionnaires:

Simulator Sickness Questionnaire (SSQ)

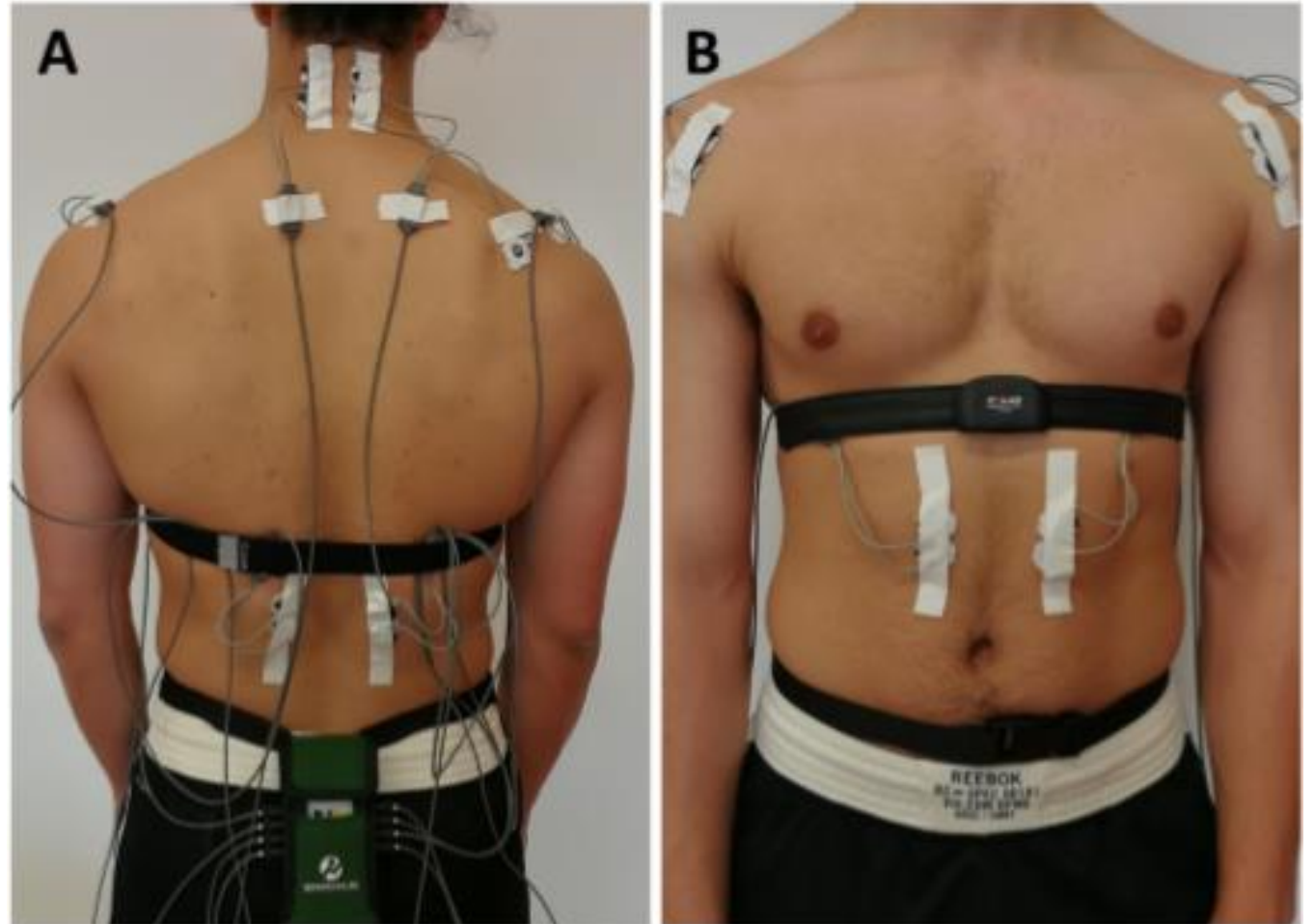Physical Activity Enjoyment Scale (PACES)

Borg Scale

NASA Task Load Index (NASA-TLX)

Heart Rate Monitor:

Participant heart rates were measured continuously using the RS800 heart rate monitor (Polar Electro).
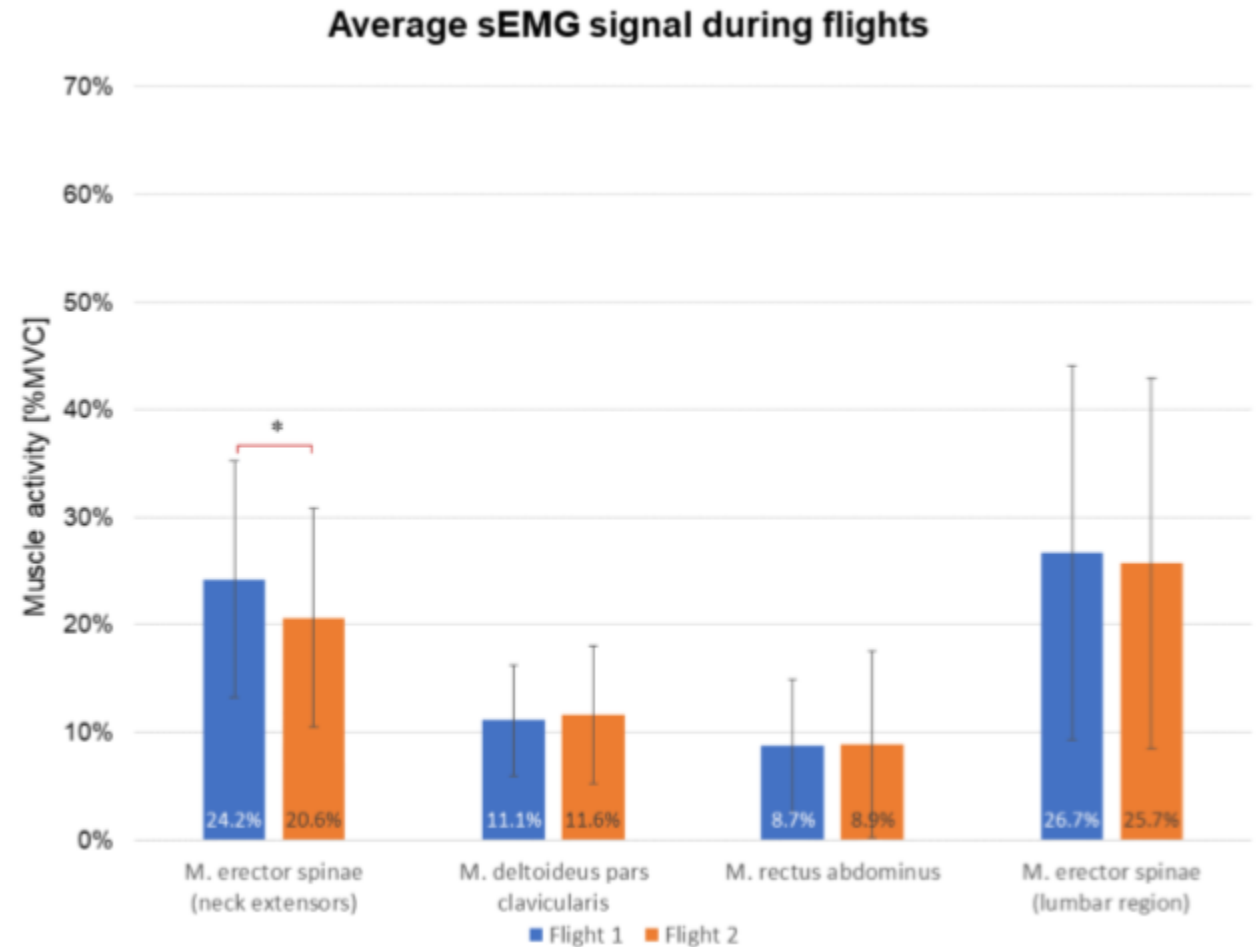
Muscle Activity:

Muscle activity was measured based on sEMG using the TeleMyo 2400T G2 (Noraxon USA).
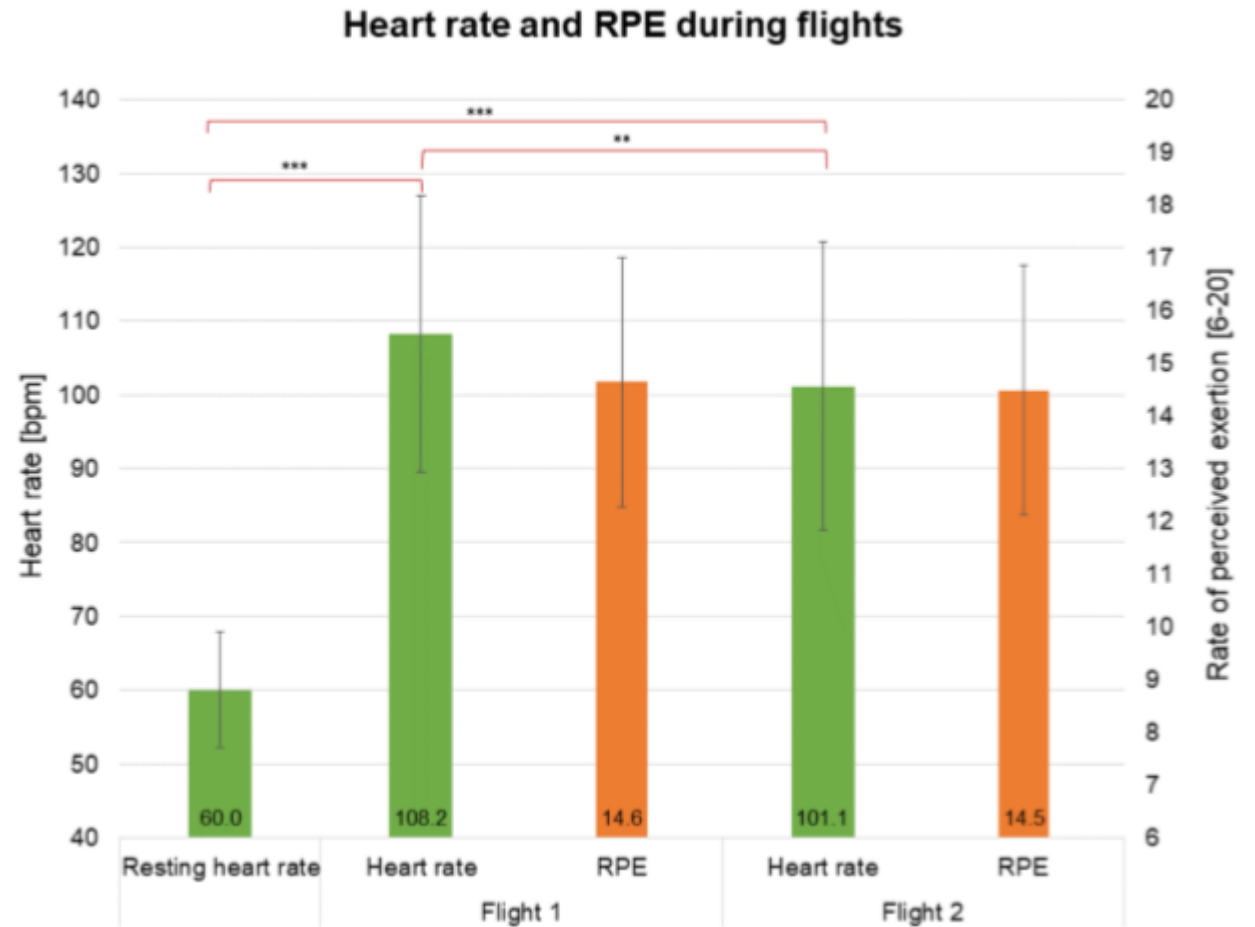
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Findings

- Dorsal muscle chain activity (neck extensors and lumbar region of m. erector spinae) shows higher levels of activation, with values reaching or crossing the 30% threshold in some cases.

- Participants position on the ICAROS device resembles the well-established plank exercise. The only difference is the device's shin holders, which provide additional support for user.

- The similarity between the average muscle activations seems to indicate the potential reliability of the ICAROS VR system. Being able to reproduce the physiological muscle activation in a consecutive flight suggests that familiarization effects do not reduce muscle activity straight away.

- Improved intermuscular coordination from reintroducing and sustaining body balance on the device after pitch and roll movements could explain why the significantly smaller range of motion did not correspond to significantly lower muscle activation during the second flight.

Average sEMG signal during flights

Study III

Results

- The lower back's muscle activation corresponds to plank variations with instability devices

- Fully immersive VR training systems can contribute to muscle-strengthening activities

- ICAROS can provide improved muscle strength, especially for the dorsal muscle chain. Differentiated muscle activation can be achieved requiring the user to spend more time in a pitch down position, thereby shifting the body's center of gravity on the pitch axis

- Training on Icaros provides a moderate cardiovascular activity (108 bpm ± 18.69)

- The ICAROS exercise is perceived as a moderate to vigorous activity (RPE 14.6 [SD 1.82])

- The exercise is perceived as an enjoyable experience (PACES 3.74 [SD 0.16])

Heart rate and RPE during flights

Study IV

"Cardiopulmonary and metabolic stress during ICAROS Cloud training"

conducted at the Faculty of Sports Science by Anna Dmitrieva ,
Ruhr- University Bochum, Bochum, Germany (2021)

Study IV

Aim

To compare differences between exercising on the ICAROS Cloud and exercising on a mat in terms of cardiopulmonary and metabolic parameters.

Findings

- Training on the ICAROS Cloud leads to an increase in cardiopulmonary and metabolic parameters compared to training on a training mat.

- The energy expenditure on the ICAROS Cloud is about 5% higher than on training on a mat.

- The lactate concentration after training on the ICAROS Cloud is 7 % higher than training on the mat. Similarly, the heart rate is also about 1 % higher on The ICAROS Cloud.

- Exercising on the ICAROS Cloud is more fun than exercising on a training mat.

- The findings clearly show that despite the tendency to be more demanding, there is a higher willingness to train on the ICAROS Cloud than the mat.
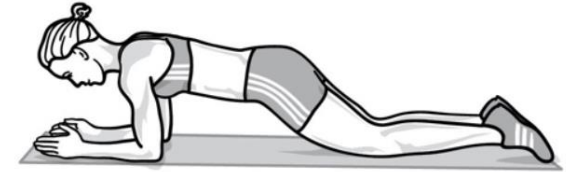
Study IV

Methods

- Cross Sectional examination of exercising on the cloud vs exercising on a training mat.

- ICAROS Cloud and Training Mat are the independent variables

- All participants performed both the trainings ordered randomly and the below mentioned variables were measured.
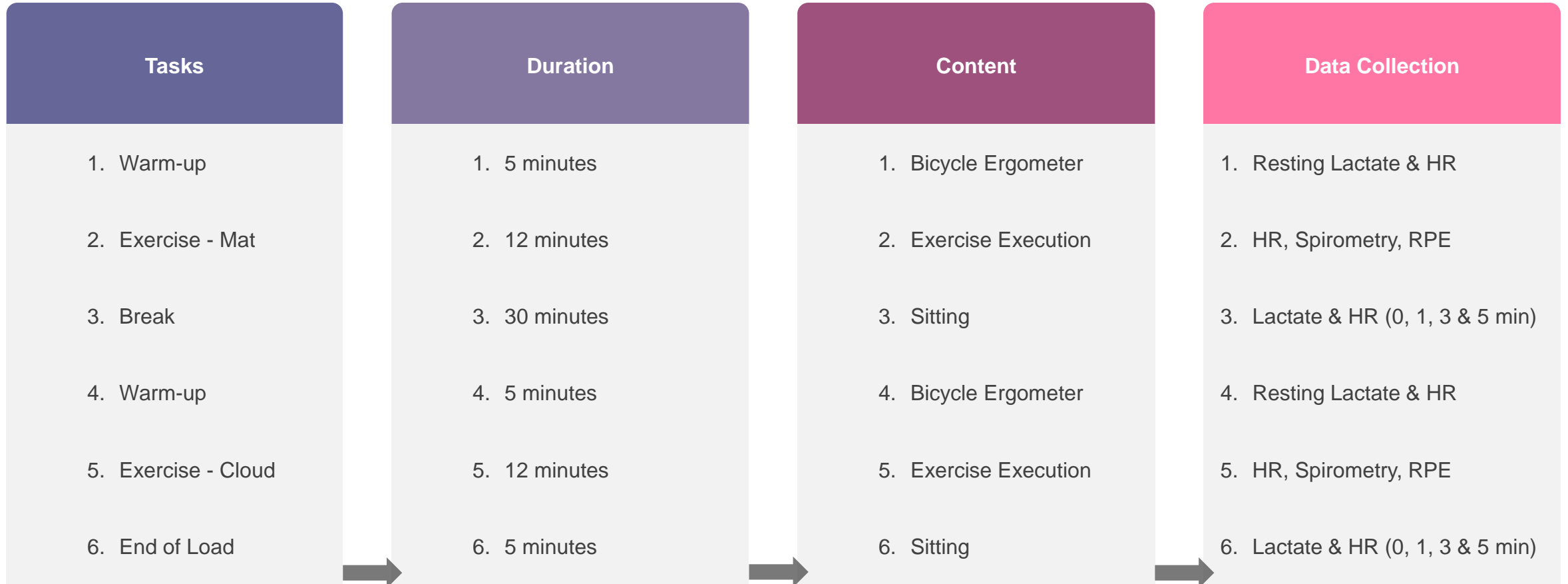
Subjects

Participants	Mean Age	Mean Height	Mean Weight
N = 16 (5 females, 11 males)	24 ± 1.5 years	176 ± 6.8 cm	71.3 ± 10.3 kg

Independent Variables	Dependent Variables (Measured Variables)
• ICAROS Cloud – Unstable training surface • Training Mat – Stable training surface	• Energy Expenditure • Heart Rate (HR) • Lactate Concentration (MetaMax 3B Spirometer) • Rate of Perceived Extraction (RPE) • PACES Questionnaire

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Study Design

Tasks	Duration	Content	Data Collection
1. Warm-up	1. 5 minutes	1. Bicycle Ergometer	1. Resting Lactate & HR
2. Exercise - Mat	2. 12 minutes	2. Exercise Execution	2. HR, Spirometry, RPE
3. Break	3. 30 minutes	3. Sitting	3. Lactate & HR (0, 1, 3 & 5 min)
4. Warm-up	4. 5 minutes	4. Bicycle Ergometer	4. Resting Lactate & HR
5. Exercise - Cloud	5. 12 minutes	5. Exercise Execution	5. HR, Spirometry, RPE
6. End of Load	6. 5 minutes	6. Sitting	6. Lactate & HR (0, 1, 3 & 5 min)

RESULTS

- **Energy Expenditure (kcal/17min)**

Energy expenditure within the exercise time and five-minute post load was about 5% higher for exercising on the ICAROS Cloud compared to exercising on the training mat albeit the effect size being small (Wilcoxon Test (p. = 0.005/ d.= 0.9/ 95% CI [1.5; 6.4])).

- Mean values :

  - ICAROS Cloud : 83 ± 15 kcal /17 min
  - Training Mat   : 79 ±16 kcal / 17 min
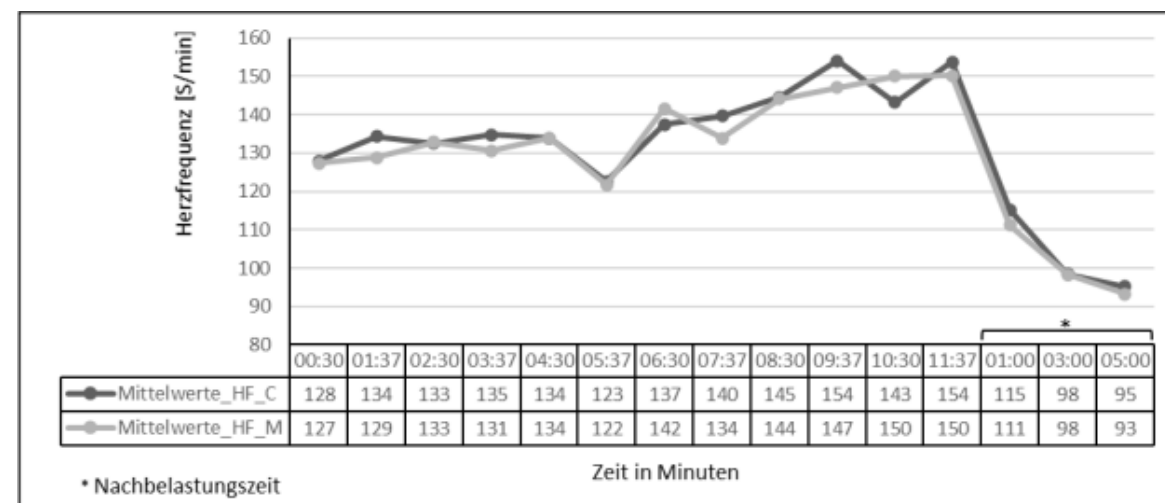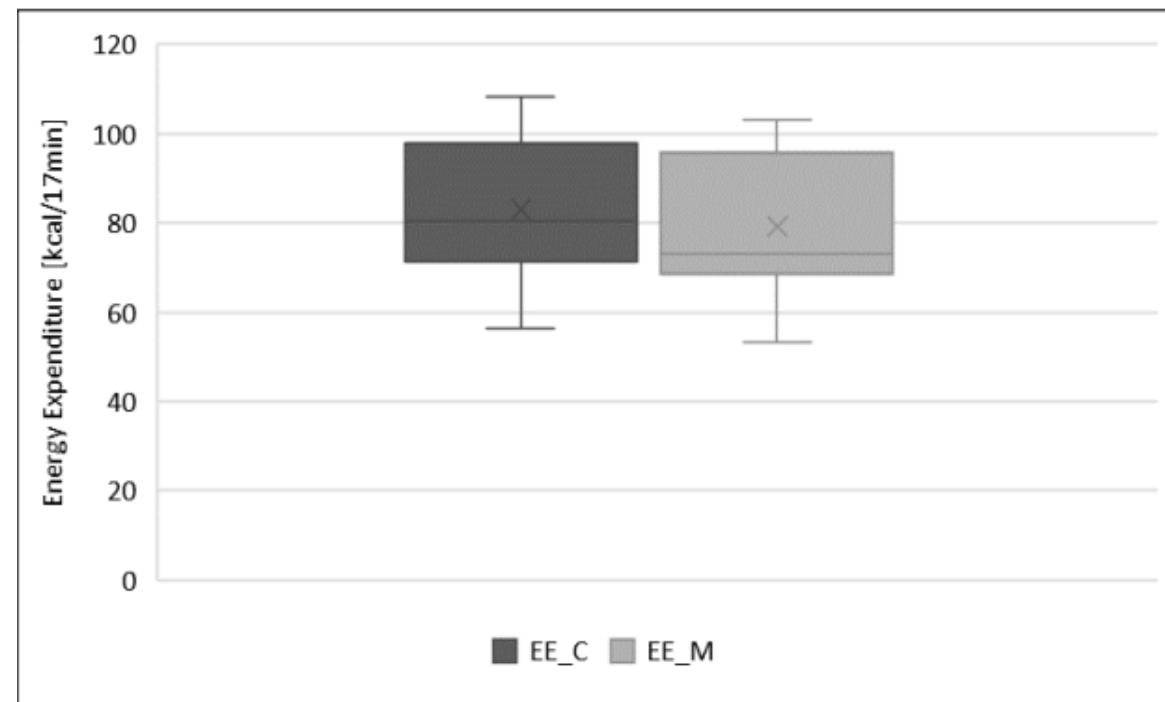
- **Heart Rate (bpm)**

T-tests for dependent samples also reveal no significance (p. = 0.209/ 95% CI [-1.7; 7.1]).

- Mean values :

  - ICAROS Cloud : 156 ± 16 bpm
  - Training Mat   : 154 ± 18 bpm

- **Lactate Concentration (mmol/l)**

Lactate concentration in the blood is more while exercising on the ICAROS Cloud (T-test (p. = 0.314/ 95% CI [-0.4; 1.2])).

- Mean values :

  - ICAROS Cloud : 5.8 ± 1.9 mmol/l
  - Training Mat   : 5.4 ± 2.1 mmol/l

	00:30	01:37	02:30	03:37	04:30	05:37	06:30	07:37	08:30	09:37	10:30	11:37	01:00	03:00	05:00
Mittelwerte_HF_C	128	134	133	135	134	123	137	140	145	154	143	154	115	98	95
Mittelwerte_HF_M	127	129	133	131	134	122	142	134	144	147	150	150	111	98	93

* Nachbelastungszeit

Zeit in Minuten

Study IV

RESULTS

- **Rate of Perceived Exertion (Borg Scale)**

  - The t-test for dependent samples does not show significance (p. = 0.909/ 95% CI [- 0.7; 0.6])

  - Mean values :

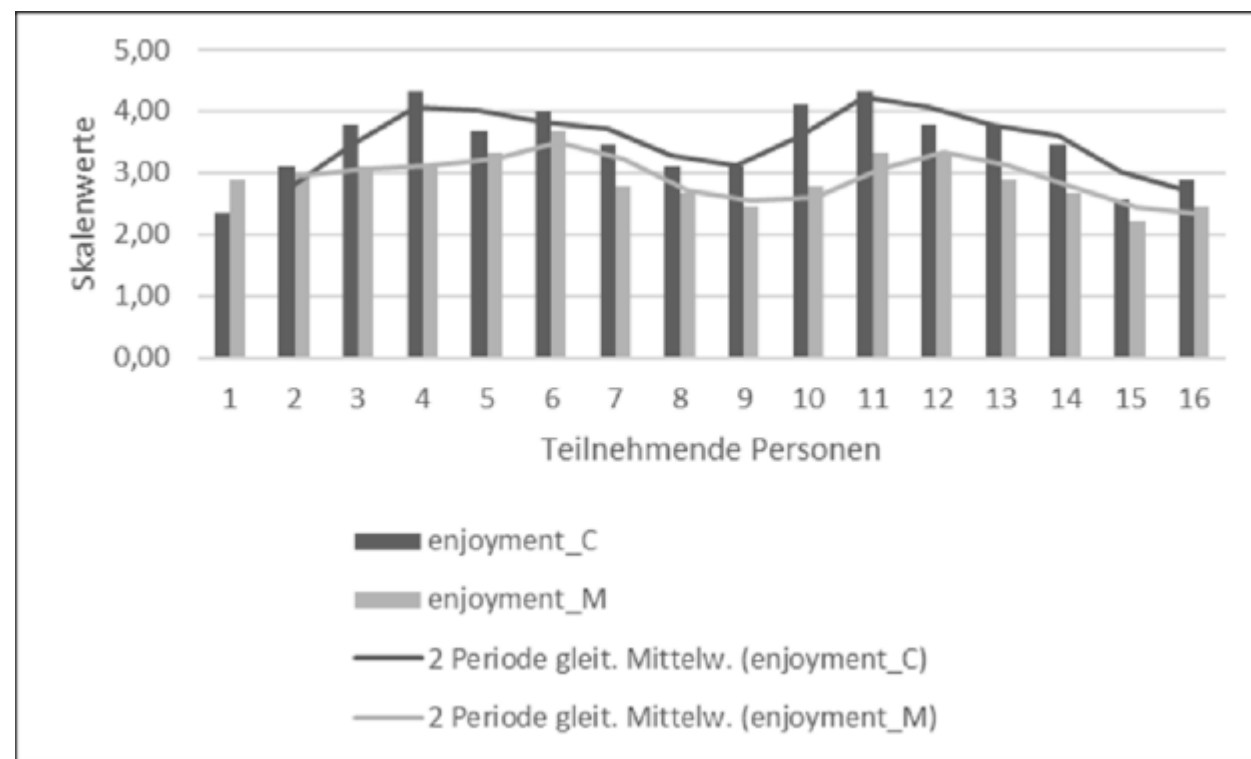   - ICAROS Cloud : 12.9 ± 1.7
    - Training Mat   : 12.9 ± 2.0

- **PACES Questionnaire**

  - Training on the ICAROS CLOUD is significantly better than training on the training mat in terms of fun factor(T-test (p. = 0.000/ 95% CI [0.3; 0.8]), with Cohen's d = 1.2.

  - Mean Values :

    - ICAROS Cloud : 3.5 ± 0.6
    - Training Mat   : 2.9 ± 0.4

	Mean ± standard deviation	Paired differences				
		Mean value	Standard deviation of the mean	95% confidence interval of the difference		Sig. (2-sideways)
				At	Upper	
RPE_CLOUD	12,9 ± 1,7	-,03571	1,22835	-,69026	,61883	,909
RPE_MATTE	12,9 ± 2,0					

Legend:
- enjoyment_C
- enjoyment_M
- 2 Periode gleit. Mittelw. (enjoyment_C)
- 2 Periode gleit. Mittelw. (enjoyment_M)

ICAROS

Conclusions

- Training on the ICAROS Cloud leads to an increase in cardiopulmonary and metabolic parameters compared to training on a training mat as is evident in the absolute values of all the measured variables even though the differences were not significant.

- The energy metabolism on the ICAROS Cloud is about 5% higher than on training on a mat. Since the trainings on both the ICAROS Cloud and Mat mirror each other, the higher calorie consumption can directly be attributed to the effectiveness of ICAROS Cloud.

- The lactate concentration after training on the ICAROS Cloud is 7 % higher than training on the mat. Similarly, the heart rate is also about 1 % higher on The ICAROS Cloud.

- In terms of 'fun factor', there is a clear and significant difference between training on the Cloud and on the mat as it is more fun to train on the ICAROS Cloud.

- The findings show that despite the tendency to be more demanding, there is a higher willingness to train on the ICAROS Cloud than the mat. This would also imply a higher willingness to train on the ICAROS Cloud and therefore a potential to increase the intensity as well as the quantity of training sessions.

Study V

"Are there improvements in core strength from regular training on the Icaros Cloud? "

conducted at the Faculty of Natural Sciences by Michaela Chalupar,
Ruhr- University of Salzburg, Austria (2021)

Study V

Aim

To investigate whether training on the ICAROS Cloud leads to improvements in:

- Trunk strength
- Fun
- Experiencing flow state

Findings

- Five weeks of training on the ICAROS Cloud resulted in a 15.85% increase in trunk strength between the pre and posts tests.

- Participants had fun while training on the ICAROS Cloud (mean rating ,m =8.11 out of 10)

- It was found that the participants were extremely absorbed in the game and training events and that all of them felt that time passed very quickly during the training on the Cloud.

Study V

Methods

Participant Demographics	Measured Variables
Number of participants, N = 9	Trunk strength : Time
	Rate of Perceived Exertion (RPE) / Borg Scale
Mean Age = 13 years	State of Flow
Sex : Females	Fun Factor

Study Design

	Week 1	• Entrance Test • Enrolment
	Weeks 2-5	• 2 x weekly training on the ICAROS Cloud 15 minute / session
	Week 5	• Final Test • Questionnaire
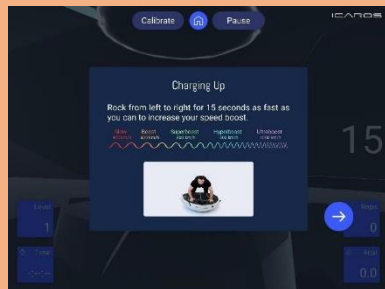
Setup of the pre and post test for the measurement of trunk muscle load-bearing capacity
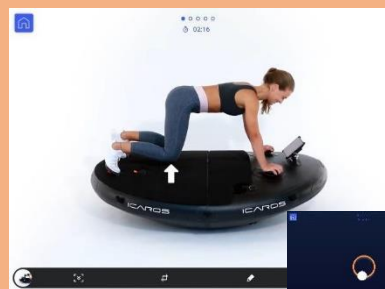
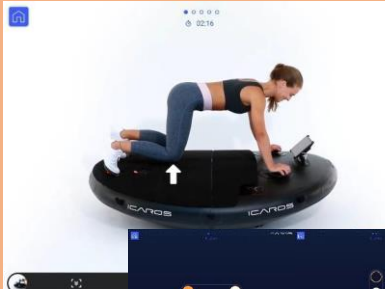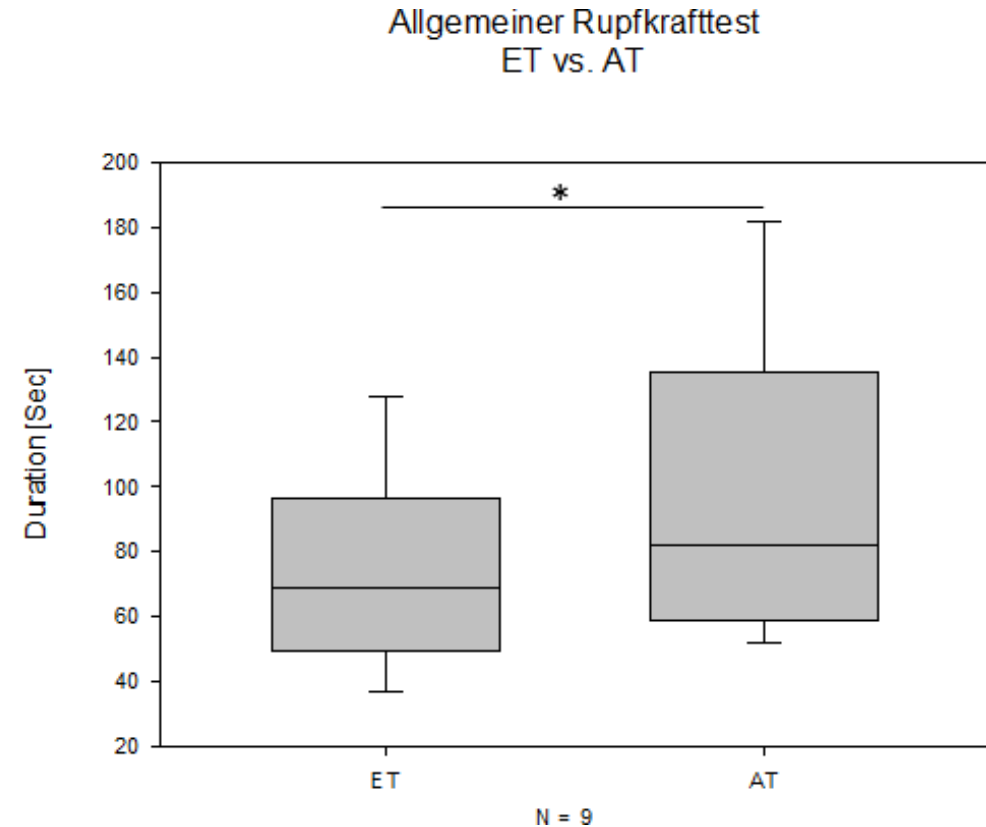# Study V

Training Programs used on the ICAROS Cloud
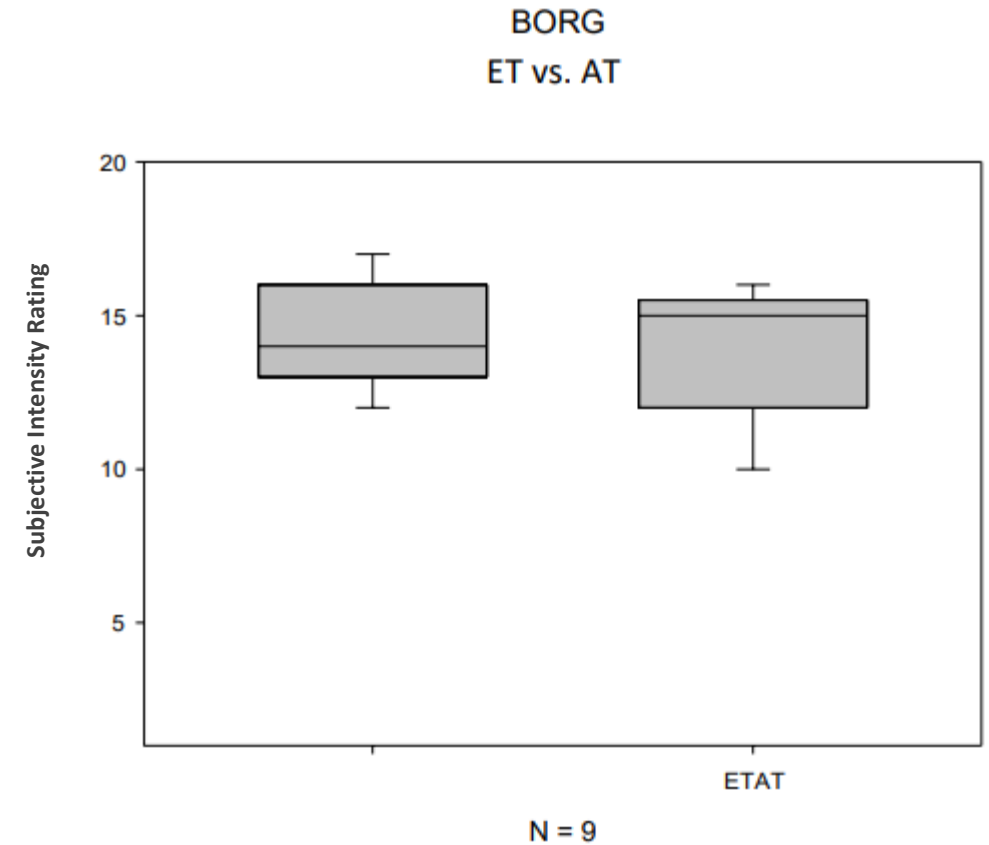
Study V

Pre-Test Time vs Post-Test Time

- Measure of Trunk Strength & Stability

- All students improved significantly in the plank position (+15.85%) suggesting improved core strength and stability.

- Using Wilcoxon signed-rank test, a significant difference (P = 0.039), (α = 0.05; β = 0.8) was found after five weeks of core training on the ICAROS Cloud.

- Median Values :
  - Pre-Test Time =   69.00 seconds
  - Post-Test Time =   82.00 seconds

Allgemeiner Rupfkrafttest
ET vs. AT

N = 9

Study V

Results

BORG Pre- Test vs Borg Post-Test

- Subjective evaluation of training intensity.

- Using a paired t-test, no significant difference ($P = 0.401$; $\alpha = 0.05$; $\beta = 0.8$) was found.

- Mean values :

  - Pre-Test = 14.556 ± 1.74
  - Post-Test = 14.00 ± 2.34

BORG
ET vs. AT

Study V

Results

Core Training

- The analysis using Spearman correlation and linear regression showed an improvement in core training.
- The range of the positive correlation coefficients of all 9 test persons was between r = 0.106 and 0.927. The mean value of the correlation coefficients was 0.551 with a standard deviation of 0.301

Fast Forward training

Squats

There was a measurable improvement in the number of squats per training session with a mean positive correlation of 0.555.
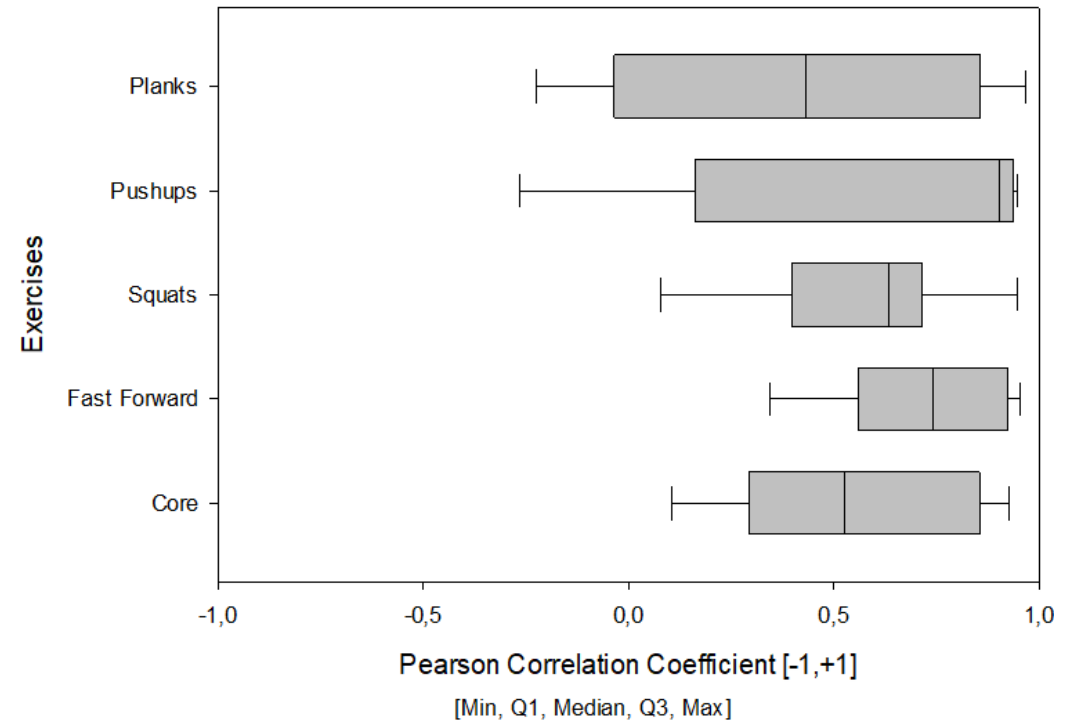
Push-ups

The number of push-ups per training session increased at a mean positive correlation of 0.620.

Planks

The mean positive correlation of 0.473 was measured for the plank push ups per training session

Box Plots (Mean of N = 9)

Exercises: Planks, Pushups, Squats, Fast Forward, Core

Pearson Correlation Coefficient [-1,+1]

[Min, Q1, Median, Q3, Max]

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<u>Conclusions</u>

- Training on the ICAROS Cloud using training programs from the ICAROS App leads to a significant increase ($p = 0.039$) in trunk strength in all the participants (+15.85 %).

- 90 % of the participants stated that they would like to continue using the ICAROS Cloud and would recommend it to others.

- The mean fun factor value as rated by the participants was 8.11 out 10, underlining that training on the ICAROS Cloud is very highly enjoyable.

- It was also observed that the test subjects were extremely absorbed during training sessions due to the gamified nature of training using the ICAROS Cloud.

- The overall conclusion of this study is that core strength is greatly improved by regular training on the ICAROS Cloud. In addition, the fun and flow factor of training on the Cloud is very high seemingly due to the gamified nature of training modalities in the ICAROS App.

Study VI

"Evaluation of ICAROS VR training on health promotion and prevention"

conducted by Armin Stegmayr*a , Egg Sabrina*b , Martha Fridrich*c , Spiegl Claudia*c , Scheiber Barbara*c and Ederer Christian*a.
Zentrum für Gesundheitsberufe Tirol GmbH (2022)

Aim

To investigate the effectiveness of training with an ICAROS PRO device and ICAROS AIM training software in Virtual Reality in terms of :

- Body Composition
- Muscle Function
- Muscle thickness
- Acceptance of participants

Findings

- 80 % of the participants wanted to continue training after the study, signifying that there is a high acceptance to ICAROS VR training.

- Reactivity of the participants increased significantly by 16.4 % from 43.0% before training to 59.4 % after training.

- Muscle functionality was found to significantly increase after training by 25.8%.

- Stability of the participants increased after training by 1.4%, which was also found to be a highly significant improvement ($p < 0.001$).

- All participants except one reported decrease in the frequency of back pain because of ICAROS VR training.

Methods

Subjects

- Total number of participants : 36
- Age group : 26 – 65

Exclusion Criteria

Medically diagnosed chronic low back pain, severe musculoskeletal injury in the last six months, pacemakers, defibrillators and age under 18 years.

Measured Variables

- Body Mass Index (BMI)

- Bio-Electrical Impedance Analysis (BIA) was used to determine body composition. BIACORPUS RX4000 was used to measure :

  - Resistance
  - Reactance
  - Phase Angle

- Biering- Sørensen test & McGil Test : Isometric Strength

- Muscle Thickness of external abdominis, obliquus internus abdominis and upper back (rhomboideus muscle) was measured using Sonoscape E2 sonography device from Fuji.
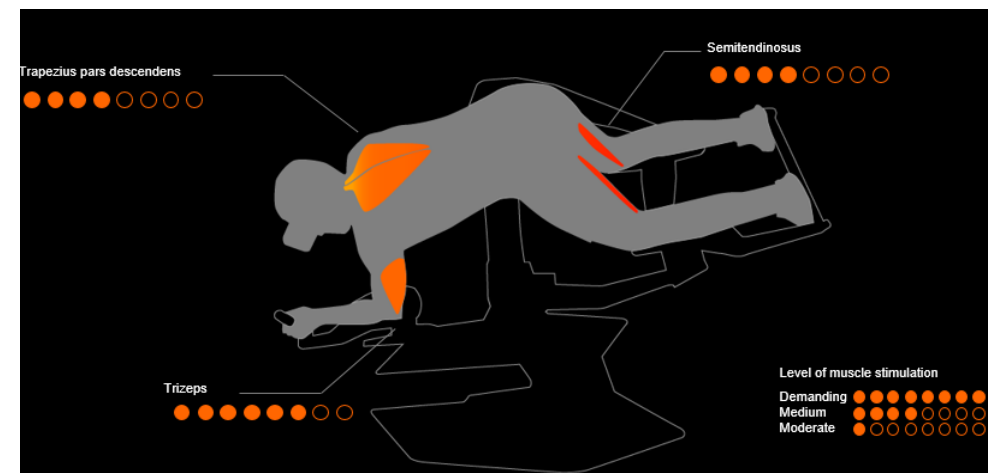
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Study Design

Pre-Test

- BIA Measurements
- Sonography
- Muscle Reactivity, functionality & Stability tests
- Questionnaire

Training (6 weeks)

- 3 sessions / week
- 10 minutes / session using ICAROS AIM Software
- Muscle Reactivity, functionality & Stability tests / week

Post Test

- BIA Measurements
- Sonography
- Questionnaire
- Muscle Reactivity, functionality & Stability tests

Follow Up

- Questionnaire

Study VI

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Results

The measurements of muscle functions show highly significant increases across variables :

- Muscle reactivity increased significantly from 43.0 % to 59.4 % by 16.4 % between pre and post training.

  - (t-test paired, t=14.5; p<0.001; d=2.42)

- Muscle functionality shows a significant increase from 37.7 % to 63.3 % and has increased by 25.8 % after training.

  - (t-Test paired; t=15.9; p<0.001; d=2.64).

- Stability shows a significant increase of 1.4 % from the initial measurement of 93.2 % to the final value of 94.6 %.

  - (t-test paired; t=8.4; p<0.001; d=1.40)
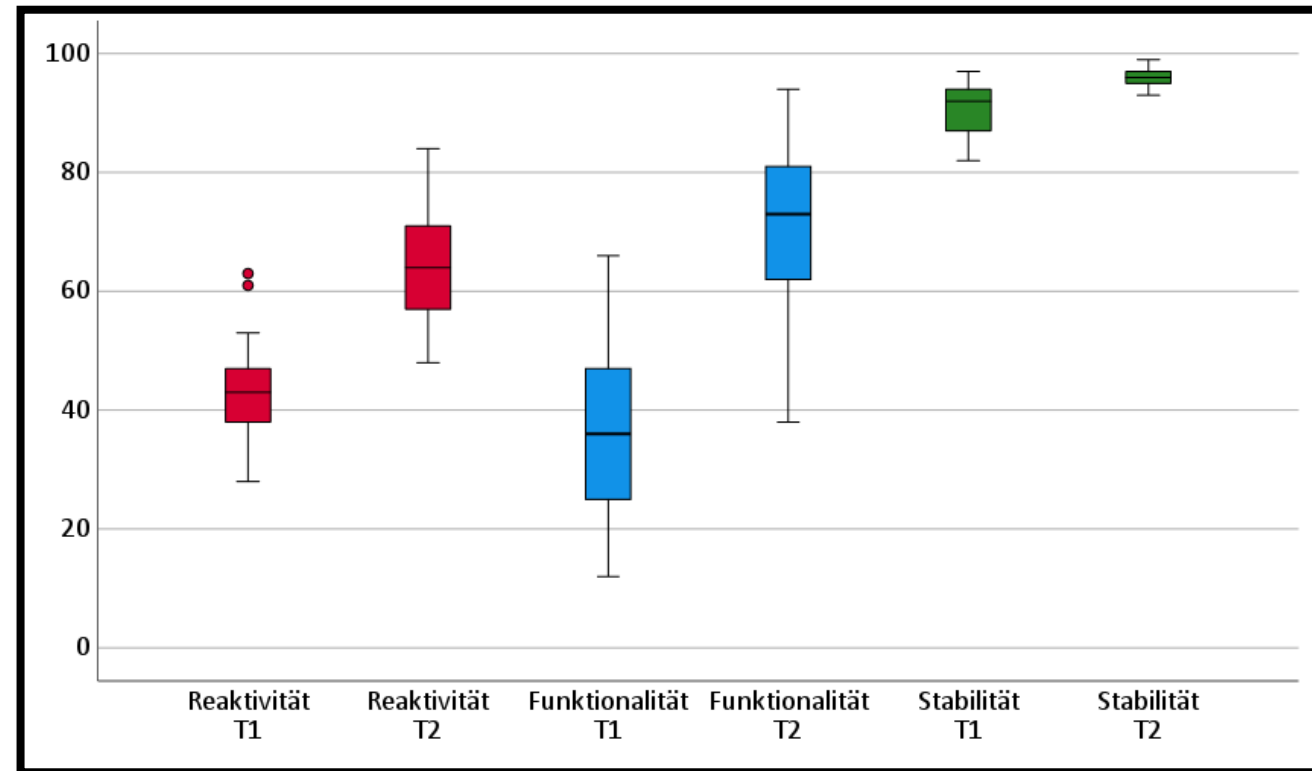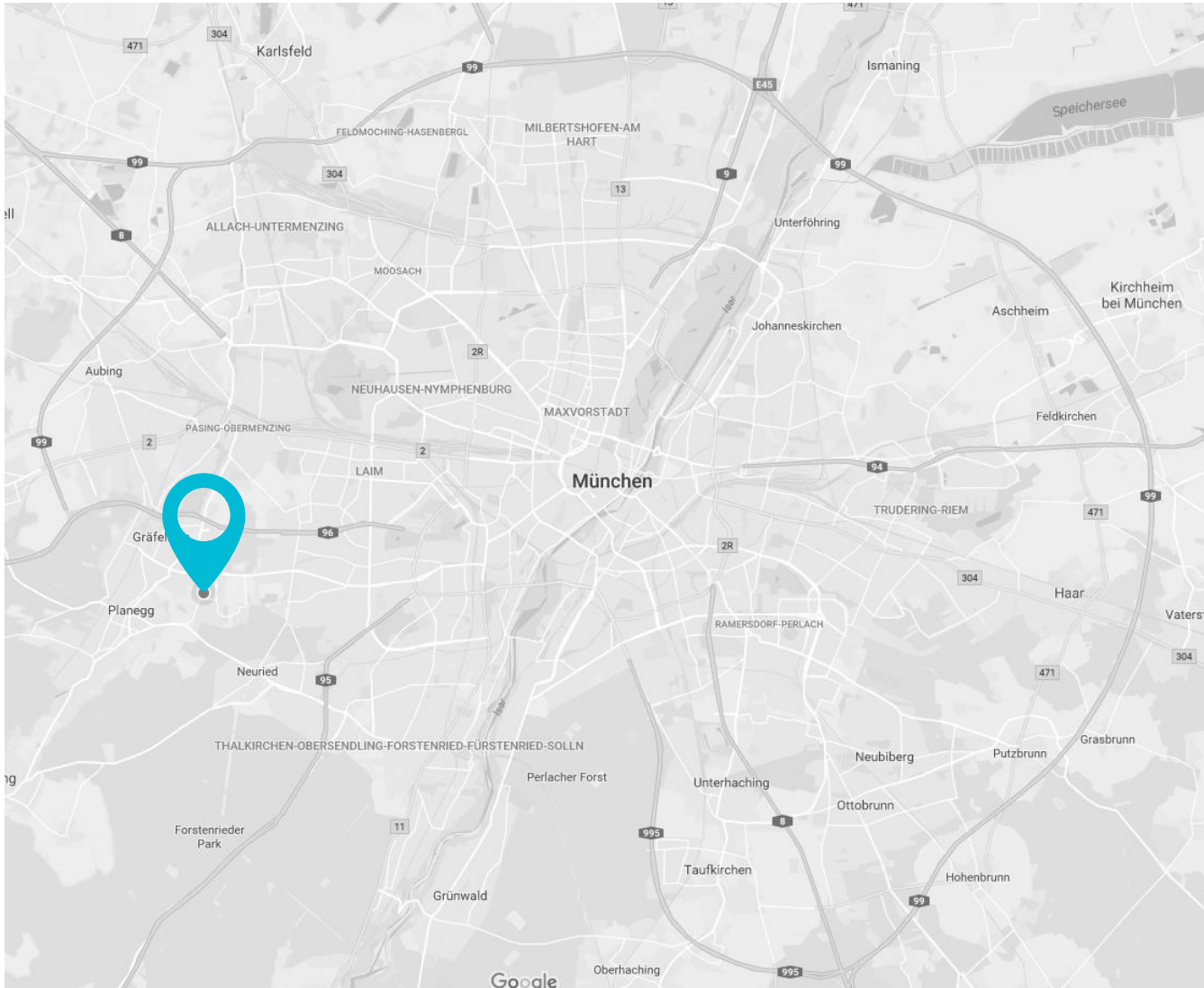
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Conclusions

- In congruence with the findings reported by previous studies, 80 % of the participants wanted to continue training with ICAROS after the study, signifying that there is a high acceptance to ICAROS VR training.

- Six weeks of training with ICAROS Pro and ICAROS AIM software was found to improve muscle functionality by 25.8% .

- Training on the ICAROS Pro using the ICAROS AIM software increased the reactivity of the participants significantly by 16.4 %, from 43.0% before training to 59.4 % after training.

- Additionally, VR training using proprietary ICAROS hardware and software significantly improved the stability of the participants by 1.4% ($p < 0.0001$).

- Regarding questions about mobility, six participants stated that the training led to an improvement of their complaints in five cases, and one person experienced a change in the localisation of the complaints.

- VR training using ICAROS hardware and software led to decrease in back pain frequency in all the participants except one, which goes in line with the results of previous studies conducted on ICAROS.

About ICAROS

Get in Touch

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ICAROS GmbH

Competencies:

Hard- and Software Development
Design and Engineering
Virtual- and Augmented Reality

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Facts & Figures:

Founded: 2015
Location: Munich
Staff: 20
Our Mission: ACTIVE VR