Use of Sensors to Improve Athletes’ Performance

driving motivation and dedication for healthy life

Marie-Elise Cernelev
Grade 7, Webber Academy

February 2021
Study Project

WHY
Better understanding of the physical motion and capture has become vital in various areas, such as competitive sports, recreational sports, and rehabilitation after different traumas.

WHAT
This research is to understand and evaluate how innovative technology (i.e. sensors) can help improve physical and athletic performance.

HOW
This will be achieved through theoretical investigation of previously published work and analysis of the relevant publications on this topic.
Background

Technology adoption
people of different physical levels/states have started using latest
technologies, such as sensors and multi-angle, and video-capture
analyses to better understand their movements

Consistent technological advancements
introduce more innovative gadgets (i.e. apps, sensors, etc.) that help
us capture physical movement, data collection, and data evaluation

Long term physical performance
is important to understand how certain physical movements can hurt
our body or enhance its physical performance in short and long run

OBJECTIVE

Evaluate and analyze various technologies
that collect physical data and quantify performance and
progression

Assess various sampling frequency and ability
to improve overall physical performance
while each technology is focused on statistical outputs by
evaluating quantities, movement precision, and movement range

WHO CAN SUBSTANTIALLY BENEFIT FROM THIS

People who are high performance athletes
who seek to further enhance their physical performance in a safe,
conscientious, and knowledge-based way

People who already have been injured
because of overexertion or trauma, which causes them to have
painful and limited mobility

People who consistently exercise
using inadequate techniques that eventually start hurting them
gradually deteriorating their mobility
If sensors can help better understand the physical motion, then we can better and faster improve physical and athletic performance.

In other words, sensors improve awareness of the physical movement and understanding/solution on how to safely improve physical and athletic performance.
# Complexity of Human Motion Movements

## COMMON RANGE OF MOTIONS

- **Extension**: Increases the angle between bones of the limb at a joint by contracting the muscles to a straightened position.
- **Flexion**: Opposite of extension, decreases the angle by bending.
- **Abduction**: Moving away from the central axis of the body.
- **Adduction**: Moving towards the central axis of the body.

## COMMON RANGE OF MOTIONS

<table>
<thead>
<tr>
<th>Flexition Type and Ranges</th>
<th>GENETICS AND SITUATIONAL</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee flexion 0 to 130 degrees extension 120 to 0</td>
<td>Muscle tissue elasticity</td>
<td>Metabolic changes</td>
</tr>
<tr>
<td>Foot inversion 0 to 35 degrees expansion 25 to 0</td>
<td>Types of joints</td>
<td>Cellular changes</td>
</tr>
<tr>
<td>Shoulder flexion from 0 to 180 degrees extension from 0 to 50 abduction from 0 to 90 adduction from 90 to 0</td>
<td>Internal resistance</td>
<td>etc.</td>
</tr>
<tr>
<td>Elbow flexion 0 to 160 degrees extension 145 to 0</td>
<td>Muscle’s ability to relax</td>
<td>etc.</td>
</tr>
<tr>
<td>Wrist flexion 0 to 90 degrees extension 0 to 70 abduction from 0 to 25 adduction from 0 to 65</td>
<td>etc.</td>
<td></td>
</tr>
</tbody>
</table>
A motion capture is when the sensors are recording the total body motion in 3D and converting information into data which can be useful for application, analyzing, markets, and research.

**SENSOR CHARACTERISTICS**

- **WEIGHT**: Minimal weight without impacting the movement
- **FREQUENCY**: High frequency reliable data measurement
- **MEASUREMENT**: Ability to record 3D position, Measure muscle strength, Measure acceleration
Comparing Technologies

**PROs**
- Easy to setup and attach
- Robustness in data gathering. No dependency on gathering data point
- Self calibration algorithms
- High potential of building full biomechanical models
- Relatively inexpensive. Some software can use your smart phones camera
- Might require additional marking on the athlete clothes
- Easy to visualize the movements. No additional software required

**CONs**
- One sensor is not enough. Need multiple sensor to capture complete motion
- Challenging to select right sensor due to narrow specialization
- Challenging extraction algorithm. Can be mitigated by using AI (Machine Learning)
- Expensive (lately getting chipper due to large demand)
- Limited to camera position and angle of recording
- Limited type of data. Mostly 3D movement.
- Ineffective for large geographical area
Applying to Swimming

Segments

**Swimming**
- Starts
- Turns
- Finishes

Control variables
- Acceleration
- Angle
- Force
- Frequency
- Duration

Analysis Category
- Temporal
- Kinematic
- Kinetic

Dependent variables
- Lap time, start time, rotation, wall contact time
- Stroke length, stroke rate, swim velocity, acceleration
- Peak impact force, horizontal impulse at wall push-off

1. Place sensor in a position to record movement
2. Experiment and record movements in action
3. Analyse data and make recommendations

---

Frontcrawl

- Acceleration (m/s²)
- Angular velocity (deg/s)

Backcrawl

- Acceleration (m/s²)
- Angular velocity (deg/s)

---

Future Directions

**USE OF AI**
**DEEP REINFORCEMENT LEARNING**
Data mining, data acquisition, and AI provide additional insight and reinforced learning that could further enhance sensor technologies.

**ASSIST WITH LIMITED PERSONAL TRAINING DURING PANDEMIC**
The sensor technology has potential during the COVID-19 pandemic, when there is limited access to in-person training, as the biofeedback could proactively be used by users to improve their movements and techniques.

**READY TO COMPLETELY REPLACE COACHING?**
While the technological and scientific advancements are already outperforming human senses, one can argue that will technology/science replace coaching?

**BIO-SENSORS**
Wearables that can access sweat, saliva, and tears to infer the relevant physiology, and ultimately full body health state. Combined with traditional wearable sensor it becomes a powerful enhancement to biomedical simulation.
Conclusion

Through this research I conclude that understanding physical motion could be significantly improved using motion sensors; consequently, rapidly improving physical and athletic performances.

KEY TAKEAWAYS

Professional athletes, recreational players, and people recovering from injuries will always aim to improve their health and performance, which can be achieved by leveraging latest scientific and technological advancements.

Modern science and technology, as well as their practical applications offer a range of benefits for users, trainers/coaches, and medical professionals/scientists.

The ability to use this technology to replace or augment limited access to professional trainers is becoming paramount in present days.

Next steps will be applying above research in a real-life experiment to quantify the impact (improvement) based on recommendation. And compare the impact of using movement sensors in different user group (grouped by uncontrolled variables like age and genetics).


