A review of wearable sensors based monitoring with daily physical activity to manage type 2 diabetes

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ABSTRACT

Globally, the aging and the lifestyle lead to rabidly increment of the number of type two diabetes (T2D) patients. Critically, T2D considers as one of the most challenging healthcare issue. Importantly, physical activity (PA) plays a vital role of improving glycemic control T2D. However, daily monitoring of T2D using wearable devices/ sensors have a crucial role to monitor glucose levels in the blood. Nowadays, daily physical activity (PA) and exercises have been used to manage T2D. The main contribution of the proposed study is to review the literature about managing and monitoring T2D with daily PA through wearable devices and sensors. Finally, challenges and future trends are also highlighted.

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1. INTRODUCTION

Nowadays, decreasing chronic diseases by changing the health behavior and improving lifestyle are critically required [1, 2]. Importantly, the use of recent trends and advanced technology in healthcare industries have gain a crucial role [3-5]. However, achieve high safety living [6-8] for elderly and patients is challenged. Thus, healthcare monitoring/tracking for those people are vital [9]. According the World Health Organization (WHO) reports, the number of T2D patients is 422 million in 2014. That means 8.5 % of adults serve from diabetes. However, WHO expects that the number will arrive to 500 million in 2030 [10]. Furthermore, there is a direct contribution between T2D and some conditions, including, stroke, heart disease, dental problems, pregnancy problems, immune system problems, nervous system disease, kidney failure, blindness, and high blood pressure [11]. In addition, diabetic patients treatment creates huge costs for institutions and governmens [12].

Physical activity (PA) [13-15] plays an important role of improving glycemic control [16] in type 2 diabetes (T2D) as shown in Figure 1 [17]. Moreover, PA achieves several healthcare goals such as [18, 19], reducing the risk of cardiovascular disease (CVD) [20, 21], increasing the vigour [22], reducing levels of triglyceride-rich VLDL [23], decreasing the insulin resistance [24, 25], improving the blood pressure (BP) [26, 27], preventing the obesity [28, 29], reducing the mortality [30, 31], improving physical
fitness [32, 33], enhance cognitive performance [34], enhance the mood [35], and increasing the energy expenditure [36, 37].

In recent years, several glucose-monitoring techniques have been conducted [38-42]. Based on the literature, still there is a lack of clarity about what level of physical activity is needed to reduce the risk of T2D [43, 44]. However, it is not clear which type of PA is better in reducing T2D risk than others. This lacking of clarity leads to the contribution of the proposed study [45-47]. The main contribution of the proposed study is to manage T2D by using wearable devices and sensors with daily physical activity. Figure 2 shows the flow chart of managing and monitoring type 2 diabetes using daily physical activity through wearable sensors. Intensity and duration are the main two measures to classify PA [48]. The metabolic equivalent (MET) is used to measure the intensity of PA [49, 50]. Table 1 shows daily physical activities and their MET.

Wearable devices [51] are now highly used for human activity recognition [52]. They are used as a predictor for any abnormal health cases [53, 54]. Importantly, diabetes patients critically need 24/7 management [55]. Monitoring the blood glucose (BG) level using wearable sensors has a vital role in diabetes treatment revolution nowadays [56-58].

![Figure 1. The effect of regular physical activity on T2D](image1)

![Figure 2. The flow chart of managing and monitoring type 2 diabetes using daily physical activity through wearable sensors](image2)

<table>
<thead>
<tr>
<th>Daily PA</th>
<th>MET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housework</td>
<td>1.8-4</td>
</tr>
<tr>
<td>Gardening</td>
<td>3.8</td>
</tr>
<tr>
<td>Shoveling</td>
<td>6</td>
</tr>
<tr>
<td>Slow walking</td>
<td>3</td>
</tr>
<tr>
<td>Fast Walking</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 1. Daily physical activities and their MET
Table 2 shows wearable sensing technologies [59-61]. The proposed study aims to review wearable sensing technologies used to manage and monitor T2D with PA. Moreover, challenges and future trends are highlighted.

Table 2. Wearable sensing technologies

<table>
<thead>
<tr>
<th>Sensor type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inertial sensor [62, 63]</td>
<td>Magnetic field sensors [64], pressure sensors [65], and accelerometer [66]</td>
</tr>
<tr>
<td>Image sensor [67]</td>
<td>Camera [68]</td>
</tr>
<tr>
<td>Location sensor [69, 70]</td>
<td>GPS and GIS [71]</td>
</tr>
<tr>
<td>Physiological sensor [72, 73]</td>
<td>Galvanic skin [74], pulse rate [75], electroencephalogram (EEG) [76, 77], electrocardiogram (ECG) [78], blood pressure sensor [79], electrooculography (EOG) [80], and spirometer [81]</td>
</tr>
</tbody>
</table>

2. LITERATURE REVIEW

Several studies and researches have been conducted to study the relationship between physical activity and T2D. That include:
- Internet of things (IoT) [82]
- Big data analytics [83]
- Signal processing based techniques [84]
- Image processing based techniques [85]
- Intelligent techniques [86]
- Data fusion techniques [87]
- Data mining techniques [88]
- Expert Systems [89]

Table 3 shows the literature of the proposed study.

Table 3. Recent advances on PA and T2D

<table>
<thead>
<tr>
<th>Reference</th>
<th>Contribution</th>
<th>Highlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>[90]</td>
<td>Combined diet and physical activity promotion programs to prevent type 2 diabetes</td>
<td>Reduce diabetes risk and decrease body weight and blood glucose levels</td>
</tr>
<tr>
<td>[91]</td>
<td>Physical activity/exercise and diabetes</td>
<td>Blood glucose management</td>
</tr>
<tr>
<td>[92]</td>
<td>Physical activity and sedentary behavior with T2D</td>
<td>Relationship of age, gender, duration of diabetes, systolic blood pressure and physical activity</td>
</tr>
<tr>
<td>[93]</td>
<td>Relationships between health literacy, motivation and diet and physical activity with T2D</td>
<td>Autonomous motivation was associated with physical activity</td>
</tr>
<tr>
<td>[94]</td>
<td>How diet, physical activity and psychosocial well-being interact in women with gestational diabetes mellitus</td>
<td>Reducing adverse impacts of gestational diabetes mellitus</td>
</tr>
<tr>
<td>[95]</td>
<td>Physical activity preferences of elderly people with T2D</td>
<td>Determine the level of physical activity of elderly people with type 2 diabetes</td>
</tr>
<tr>
<td>[96]</td>
<td>Development of wearable physiologic monitoring devices for use in diabetes management</td>
<td>Enhance continuous glucose monitoring</td>
</tr>
<tr>
<td>[97]</td>
<td>Designing an internet-of-things (IoT) and sensor-based in-home monitoring system for assisting diabetes patients</td>
<td>Implementation of an internet-of-things (IoT) and wireless sensor system which patients use in their own homes to capture daily activity</td>
</tr>
<tr>
<td>[98]</td>
<td>Continuous movement monitoring of daily living activities</td>
<td>Prevention of diabetic foot ulcer</td>
</tr>
<tr>
<td>[99]</td>
<td>Glucose monitoring in individuals with diabetes</td>
<td>Long-term implanted sensor/telemetry system and model are used</td>
</tr>
<tr>
<td>[100]</td>
<td>Sensor-based method for glucose monitoring</td>
<td>Accuracy, safety and acceptability of the glucose monitoring system in the paediatric population is proposed</td>
</tr>
<tr>
<td>[101]</td>
<td>Continuous glucose monitoring sensors</td>
<td>Past and present algorithmic challenges of CGM sensors are introduced</td>
</tr>
<tr>
<td>[102]</td>
<td>Continuous glucose monitoring</td>
<td>Use of CGM for adjustment of insulin dosing, and automated interpretation</td>
</tr>
<tr>
<td>[103]</td>
<td>Continuous glucose monitoring</td>
<td>Reduce the risk of hypoglycemia</td>
</tr>
<tr>
<td>[104]</td>
<td>T2D management</td>
<td>Big data technologies</td>
</tr>
<tr>
<td>[105]</td>
<td>T2D management</td>
<td>Predictive models using big data analytics</td>
</tr>
<tr>
<td>[106]</td>
<td>The relationship between diet, physical activity, and T2D</td>
<td>Regular PA is a primary component in management of T2D</td>
</tr>
<tr>
<td>[107]</td>
<td>The relationship between physical activity and T2D</td>
<td>Level of physical activity in people with T2D is analyzed</td>
</tr>
<tr>
<td>[108]</td>
<td>Physical activity and incident type 2 diabetes mellitus</td>
<td>Dose–response meta-analysis of prospective cohort studies</td>
</tr>
<tr>
<td>[109]</td>
<td>Physical activity and risk of diabetes</td>
<td>PA is associated with reduction in the risk of diabetes</td>
</tr>
<tr>
<td>[110]</td>
<td>Sensor based monitoring of PA to improve glucose management</td>
<td>Non-invasive sensors using physiological parameters related to PA to improve glucose monitoring</td>
</tr>
<tr>
<td>[111]</td>
<td>Continuous glucose monitoring</td>
<td>Minimally non-invasive Continuous glucose monitoring biosensors are proposed</td>
</tr>
</tbody>
</table>
3. CHALLENGES

This section summarizes challenges and future trends for wearable sensors based monitoring with daily physical activity to manage type 2 diabetes, including [101, 102, 112-114]:

- PA level: yet, there is a lack of clarity about what level of PA is needed to reduce the risk of T2D.
- PA Diversity: definition of the activities characteristics is challenging issue.
- Accuracy: does continuous glucose monitoring is accurate enough to be reliable measure for glucose level for dosing insulin.
- Privacy and security: helatcare data is sensitive data.
- Availability: detect failures of the sensor is very crucial.
- Cost: continuous monitoring is very costly process.
- Patient acceptance: the wearable device should be acceptable and comfortable by the wearer, in terms of, size, shape, design, skin placement, and safety.
- Sensor calibration: reduce the impact of individual quasi-stable factors is critical.
- Energy efficiency: continuous monitoring is energy consuming.
- Noise and uncontrolled environment: background noise may affect performance, accuracy, precision.
- Big data, Bandwidth, and computational time: continuous monitoring provides a huge amount of data [115, 116].

4. CONCLUSION

Recent advances in the healthcare enhance healthcare industris and medical services. However, the latest advances of technology and communication, such as internet of things (IoT) have a vital role in disease diagnosis and monitoring. However, the internet of medical things (IoMT) has an ability to continuous and remote real-time monitoring of T2D. However, PA plays an important role of improving glycemic control. Importantly, wearable devices/sensors have the potential to monitor continuously and non-invasively T2D. The main aim of the proposed review study is to find visible solutions to enhance the healthcare living facilities using remote health monitoring (RHM). Moreover, the proposed review study highlighted wearable sensors based monitoring with daily physical activity to manage type 2 diabetes. Furthermore, personalized, continuous, preventive and proactive diabetes management is also proposed. Finally, challenges and future trends are discussed and highlighted.

REFERENCES


A review of wearable sensors based monitoring with daily physical activity to manage ... (Omar AlShorman)


A review of wearable sensors based monitoring with daily physical activity to manage...

Omar AlShorman