ORIGINAL ARTICLE
The Economic Costs Associated with Physical Inactivity and Obesity in Ontario
Peter T. Katzmarzyk

Abstract
Background: Physical inactivity and obesity are highly prevalent in every Canadian province and territory. Purpose: To estimate the economic costs of physical inactivity and obesity for the province of Ontario in 2009. Methods: A prevalence-based economic burden analysis was undertaken. The relative risks of diseases associated with physical inactivity and obesity were determined from a meta-analysis of existing prospective studies and applied to the health care costs of these diseases in Ontario. The prevalences of physical inactivity and obesity were obtained from the 2009 Canadian Community Health Survey (CCHS) for the province of Ontario. Estimates of the economic burden were derived from both direct and indirect expenditure categories. Direct medical costs included hospital care expenditures, drug expenditures, physician care expenditures, expenditures for care in other institutions, and additional direct health expenditures; whereas indirect costs included the value of years of life lost due to premature death and the value of days lost due to short-term and long-term disability.
Results: The prevalences of physical inactivity (<1.5 kcal·kg⁻¹·day⁻¹ of leisure time energy expenditure) and obesity (body mass index ≥30 kg/m²) among Ontario adults for 2009 were 49.3% and 25.4%, respectively. The economic burden of physical inactivity was $3.4 billion ($1.02 billion in direct costs and $2.34 billion in indirect costs) while the burden associated with obesity was $4.5 billion ($1.60 billion in direct costs and $2.87 billion in indirect costs).

Keywords: overweight; exercise; economic burden; cost-of-illness; population attributable risk; lifestyle

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Introduction
National estimates of the economic burden attributed to obesity and physical inactivity have been reported for Canada (Anis et al., 2010; Birmingham et al., 1999; Katzmarzyk et al., 2000; Katzmarzyk and Janssen, 2004). However, these estimates will vary from province to province due to regional differences in the prevalences of physical inactivity and obesity and total provincial health care expenditures. The economic costs of physical inactivity and obesity have been previously reported for Ontario for 2001 (Katzmarzyk and Janssen, 2003). At that time the cost associated with physical inactivity was estimated at $1.8 billion ($634 million direct, $1.2 billion indirect) and the cost associated with obesity was estimated at $1.6 billion ($647 million direct, $905 million indirect). These estimates are now 10 years old, and given that there have been increases in total medical expenditures in Ontario as well as changes in the prevalences of physical inactivity and obesity, these estimates may no longer provide an accurate assessment of the current situation.
Economics of Inactivity and Obesity

The purpose of this study is to update the economic cost estimates for physical inactivity and obesity for Ontario in 2009, and to estimate trends in costs over time. Potential temporal changes in the cost estimates may be due to changes in the prevalence of physical inactivity and obesity, as well as increases in medical expenditures within the province of Ontario between 2001 and 2009.

Methods
The economic costs of physical inactivity and obesity in Ontario were estimated using a prevalence-based approach. In order to ensure comparability to an earlier report on the economic costs of physical inactivity and obesity in Canada (Katzmarzyk and Janssen, 2004), the same analytical strategy was employed in the current report. First, the relationships between physical inactivity, obesity and associated chronic diseases were obtained from a published meta-analysis of prospective longitudinal studies (Katzmarzyk and Janssen, 2004). Summary relative risk (RR) estimates were calculated using a general variance-based method of meta-analysis. Seven chronic diseases have been consistently shown to be associated with physical inactivity, including coronary artery disease, stroke, hypertension, colon cancer, breast cancer, type 2 diabetes, and osteoporosis. There are sufficient long-term prospective studies to identify eight diseases associated with obesity, which include coronary artery disease, stroke, hypertension, colon cancer, post-menopausal breast cancer, type 2 diabetes, gall bladder disease and osteoarthritis.

The impacts of physical inactivity and obesity on society were then estimated by calculating the population attributable risks (PAR%) for each disease, which combines the summary RR estimate with the population prevalence (P) of physical inactivity or obesity as follows: \( \text{PAR} = \frac{[P(\text{RR}-1)]}{1+[\text{RR}-1]} \).

For the purpose of calculating the PAR%, the prevalences of physical inactivity and obesity in Ontario were obtained from the 2009 Canadian Community Health Survey (CCHS). The prevalence of physical inactivity [expenditures < 6.3 kJ kg\(^{-1}\) day\(^{-1}\) (<1.5 kcal kg\(^{-1}\) day\(^{-1}\))] in leisure-time among Ontarians 12 years and older was 49.3% in the 2009 CCHS (Statistics Canada, 2011), so this value was used to model the economic costs of physical inactivity in this report.

The true prevalence of obesity (body mass index [BMI] ≥ 30 kg/m\(^2\)) (Health Canada, 2003) among Ontario adults was estimated from self-reported height and weight data from the 2009 CCHS among adults 18 years of age and older. The self-reported prevalence of obesity in Ontario in 2009 was 17.4% (Statistics Canada, 2011). However, given the known bias in using self-reported data (people tend to under-report their weight and over-report their height) (Connor Gorber et al., 2007), this estimate was adjusted upwards to better reflect the true prevalence by applying a factor derived from data from the 2008 CCHS in which both self-reported and measured BMI data were collected. In that survey, the self-reported prevalence was 17.2%, and the measured prevalence was 25.1%. Thus, a correction factor of 1.4593 (25.1/17.2) was applied to the 17.4% prevalence of self-reported obesity for Ontario in 2009, resulting in an estimated prevalence of 25.4%, which was used to estimate the economic costs of obesity in this report.

The direct and indirect costs of the diseases related to (not attributed to)
physical inactivity and obesity were primarily estimated from information on 
the costs of specific diseases in the Economic Burden of Illness in Canada, 
1998 (EBIC 1998; Health Canada, 2002) and in the Economic Burden of Illness in 
Canada, 1993 (EBIC 1993; Moore et al., 1997). Direct costs are defined as the 
values of goods and services for which payment was made and resources used in 
treatment, care, and rehabilitation related to illness or injury. The five direct cost 
components of the EBIC 1998 include hospital care expenditures, drug 
expenditures, physician care expenditures, expenditures for care in 
other institutions, and additional direct health expenditures (including other 
professionals, public health, health research, prepayment administration, 
etc.).

Indirect costs are defined as the value of economic output lost because of illness, 
injury-related work disability, or premature death. The indirect cost 
components in the EBIC 1998 were measured in terms of the value of years of 
life lost due to premature death and the value of activity days lost due to short-
term and long-term disability.

The specific costs associated with some diseases were not directly reported 
in the EBIC 1998 and were therefore estimated using the following approaches. The EBIC 1998 reported the total direct 
and indirect costs of treating cardiovascular disease, but did not have 
specific costs for coronary artery disease, stroke, and hypertension. The costs of 
coronary artery disease and stroke for 1998 were estimated by multiplying the 
proportional costs associated with treating coronary artery disease (28.2% 
direct, 42.8% indirect) and stroke (19.6% 
direct, 9.9% indirect) relative to total 
cardiovascular disease costs that were 
reported in the EBIC 1993. The cost of 
treating hypertension in 1998 was estimated by multiplying the proportion 
of direct (17.8%) and indirect (9.2%) 
cardiovascular disease costs attributable 
to hypertension in the United States 
(American Heart Association, 2002).

The EBIC 1998 provided direct and 
indirect costs for all cancers combined, 
and we estimated the costs of treating 
colon and breast cancers using the actual 
incidence of colon (9.0%) and breast 
(14.4%) cancers relative to all newly 
diagnosed cancers in Canada in 1998 
(National Cancer Institute of Canada, 
2002). The costs of treating post-
menopausal breast cancer was calculated 
using the estimated incidence of breast 
cancer in 50+ year old women relative to 
all Canadian women in 2002 (78%) 
(National Cancer Institute of Canada, 
2002).

The EBIC 1998 reported the direct 
and indirect costs of treating endocrine 
and related diseases, but did not have a 
specific cost for diabetes. The cost of type 
2 diabetes in 1998 was estimated by 
multiplying the proportion of the direct 
(43.3%) and indirect (26.8%) endocrine 
diseases costs that were attributable to 
diabetes in the EBIC 1993 and by the 
proportion of diabetes cases that are type 
2 diabetes (92.5%) (U.S. Centers for 
Disease Control and Prevention, 1997).

The EBIC 1998 reported the direct 
and indirect costs of treating digestive 
diseases, but did not have a specific cost 
for gall bladder disease. The proportion of 
digestive diseases cost that was 
attributable to gall bladder disease in 
1998 (15.5%) was calculated by 
multiplying the cost associated with gall 
bladder disease in the United States in 
1986 (Colditz, 1992) relative to the cost 
of treating all digestive diseases in the 
United States in 1980 (Hodgson and
Kopstein, 1984), after the 1980 value was converted to a 1986 value using the medical component of the U.S. Consumer Price Index (U.S. Department of Labor and Bureau of Labor Statistics, 2003).

The **EBIC 1998** reported the direct and indirect costs of treating musculoskeletal diseases, but did not have a cost specifically for osteoarthritis or osteoporosis. The cost of osteoarthritis in 1998 was estimated by multiplying the cost for all musculoskeletal diseases relative to the proportion of musculoskeletal diseases in Ontario that are arthritis (68.2%) (Badley et al., 1994) and the proportion of arthritis cases that are osteoarthritis (49.2%) (Lawrence et al., 1998). The proportion of the direct and indirect costs of treating musculoskeletal diseases in the **EBIC 1998** that were attributable to osteoporosis were determined by dividing the previously calculated direct cost for osteoporosis in Canada in 1993 ($744.4 million) (Goeree et al., 1996), by the total direct cost of musculoskeletal diseases in the **EBIC 1993** (30.3%).

The final step in estimating the health care costs of physical inactivity and obesity was to apply the PAR% values calculated from the RR of disease and population prevalences of physical inactivity and obesity to the health costs derived from the **EBIC 1998** as described above. In this way, the health-care costs directly attributable to physical inactivity and obesity were determined. The health care costs calculated for the diseases of interest in the **EBIC 1998** were inflated to 2009 dollars by using the percentage increase in total health care costs between 1998 ($33,083.7 million) and 2009 ($71,581.6 million) in Ontario (116.4% increase) reported in the National Health Expenditures Database (Canadian Institute for Health Information, 2010) and by assuming that each disease made up a similar percentage of total health care expenditures in 1998 and 2001.

The health care costs for each disease specific for Ontario were determined by multiplying the Canadian values by the proportion of the Canadian costs incurred in Ontario in 2009 (39.3%) (Canadian Institute for Health Information, 2010). These estimates were reported by CIHI, and included public and private health care expenditures (Canadian Institute for Health Information, 2010). The same proportion (39.3%) was applied for direct and indirect costs.

**Results**

The summary RR estimates for each of the diseases associated with physical inactivity and obesity are presented in Table 1. The higher risk of disease due to physical inactivity ranges from 30% for hypertension to 60% for stroke, while the increased risks of disease associated with obesity ranges from 45% for colon cancer to 350% for hypertension (Katzmarzyk and Janssen, 2004).

The PAR% is a statistic that couples the RR of a disease due to a given risk factor with the prevalence of the risk factor in the population, and reflects the burden of that disease in society that is directly attributable to that risk factor. The PAR% attributable to physical inactivity and obesity for each of the diseases are shown in Table 1. The PAR% values indicate that between 12.9% (hypertension) and 22.8% (stroke) of the chronic diseases that are associated with physical inactivity in Ontario are directly attributable to physical inactivity. Likewise, between 10.3% (colon cancer) and 47.1% (hypertension) of the chronic diseases associated with obesity in Ontario are attributable to obesity.
The total economic burden of physical inactivity (Table 2) was $3.4 billion ($1.02 billion in direct costs and $2.34 billion in indirect costs) while the cost associated with obesity (Table 3) was $4.5 billion ($1.60 billion in direct costs and $2.87 billion in indirect costs) in Ontario for the year 2009. The three most expensive diseases associated with physical inactivity were coronary artery disease ($1.1 billion), osteoporosis ($951 million), and stroke ($483 million); these three diseases accounted for 74% of the total economic costs of physical inactivity. The three most expensive diseases associated with obesity were coronary artery disease ($1.4 billion), hypertension ($954 million), and osteoarthritis ($939 million); these three diseases accounted for 74% of the total economic costs of obesity.

Table 1: Summary relative risks (RR) and population attributable risks (PAR%) for physical inactivity and obesity in Ontario, 2009.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Summary RR</th>
<th>95% CI</th>
<th>PAR%**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Inactivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary Artery Disease</td>
<td>1.45</td>
<td>(1.38-1.54)</td>
<td>18.2</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.60</td>
<td>(1.42-1.80)</td>
<td>22.8</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.30</td>
<td>(1.16-1.46)</td>
<td>12.9</td>
</tr>
<tr>
<td>Colon Cancer</td>
<td>1.41</td>
<td>(1.31-1.53)</td>
<td>16.8</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>1.31</td>
<td>(1.23-1.38)</td>
<td>13.3</td>
</tr>
<tr>
<td>Type 2 Diabetes</td>
<td>1.50</td>
<td>(1.37-1.63)</td>
<td>19.8</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>1.59</td>
<td>(1.40-1.80)</td>
<td>22.5</td>
</tr>
<tr>
<td><strong>Obesity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary Artery Disease</td>
<td>2.24</td>
<td>(2.04-2.45)</td>
<td>24.0</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.50</td>
<td>(1.28-1.77)</td>
<td>11.3</td>
</tr>
<tr>
<td>Hypertension</td>
<td>4.50</td>
<td>(4.15-4.84)</td>
<td>47.1</td>
</tr>
<tr>
<td>Colon Cancer</td>
<td>1.45</td>
<td>(1.23-1.71)</td>
<td>10.3</td>
</tr>
<tr>
<td>Post-menopausal Breast Cancer</td>
<td>1.47</td>
<td>(1.40-1.54)</td>
<td>10.7</td>
</tr>
<tr>
<td>Type 2 Diabetes</td>
<td>3.73</td>
<td>(3.45-4.06)</td>
<td>40.9</td>
</tr>
<tr>
<td>Gall Bladder Disease</td>
<td>3.33</td>
<td>(2.86-3.85)</td>
<td>37.2</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>1.99</td>
<td>(1.76-2.24)</td>
<td>20.1</td>
</tr>
</tbody>
</table>

*RRR estimates are from the meta-analysis of Katzmarzyk and Janssen (2004).
**The PAR% was computed using prevalences of physical inactivity and obesity from the 2009 Canadian Community Health Survey, as described in the methods.
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Table 2: Direct and indirect costs ($ millions) of major chronic diseases associated with physical inactivity in Ontario in 2009 and estimated costs attributable to physical inactivity.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Direct Costs</th>
<th>Indirect Costs</th>
<th>Direct Cost Attributable to Inactivity</th>
<th>Indirect Cost Attributable to Inactivity</th>
<th>Total Cost Attributable to Inactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary Artery Disease</td>
<td>1634.9</td>
<td>4241.7</td>
<td>296.9</td>
<td>770.2</td>
<td>1067.0</td>
</tr>
<tr>
<td>Stroke</td>
<td>1136.3</td>
<td>981.1</td>
<td>259.4</td>
<td>224.0</td>
<td>483.4</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1032.0</td>
<td>995.9</td>
<td>133.0</td>
<td>128.1</td>
<td>261.3</td>
</tr>
<tr>
<td>Colon Cancer</td>
<td>188.4</td>
<td>899.8</td>
<td>31.7</td>
<td>151.3</td>
<td>183.0</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>301.5</td>
<td>1439.8</td>
<td>40.0</td>
<td>190.9</td>
<td>230.8</td>
</tr>
<tr>
<td>Type 2 Diabetes</td>
<td>539.6</td>
<td>396.3</td>
<td>106.7</td>
<td>78.4</td>
<td>185.1</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>682.4</td>
<td>3538.2</td>
<td>153.8</td>
<td>797.3</td>
<td>951.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1021.3</strong></td>
<td><strong>2340.2</strong></td>
<td><strong>3361.6</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Direct and indirect costs ($ millions) of major chronic diseases associated with obesity in Ontario in 2009 and estimated costs attributable to obesity.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Direct Costs</th>
<th>Indirect Costs</th>
<th>Direct Cost Attributable to Obesity</th>
<th>Indirect Cost Attributable to Obesity</th>
<th>Total Cost Attributable to Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary Artery Disease</td>
<td>1634.9</td>
<td>4241.7</td>
<td>391.6</td>
<td>1016.0</td>
<td>1407.6</td>
</tr>
<tr>
<td>Stroke</td>
<td>1136.3</td>
<td>981.1</td>
<td>128.0</td>
<td>110.6</td>
<td>238.6</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1032.0</td>
<td>995.9</td>
<td>485.7</td>
<td>488.7</td>
<td>954.4</td>
</tr>
<tr>
<td>Colon Cancer</td>
<td>188.4</td>
<td>899.8</td>
<td>19.3</td>
<td>92.3</td>
<td>111.6</td>
</tr>
<tr>
<td>Post-menopausal Breast Cancer</td>
<td>235.2</td>
<td>1123.0</td>
<td>25.1</td>
<td>119.8</td>
<td>144.9</td>
</tr>
<tr>
<td>Type 2 Diabetes</td>
<td>539.6</td>
<td>396.3</td>
<td>221.0</td>
<td>162.3</td>
<td>383.2</td>
</tr>
<tr>
<td>Gall Bladder Disease</td>
<td>466.6</td>
<td>305.0</td>
<td>173.5</td>
<td>113.4</td>
<td>286.9</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>755.7</td>
<td>3910.3</td>
<td>151.8</td>
<td>787.3</td>
<td>939.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1596.0</strong></td>
<td><strong>2870.3</strong></td>
<td><strong>4466.3</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Proportions of the costs of A) physical inactivity and B) obesity attributable to specific diseases in Ontario in 2009.
Discussion

The results presented in this study indicate that obesity and physical inactivity continue to be major contributors to the public health burden in Ontario. A previous report that employed the same methodology estimated that in 2001 in Ontario the economic burden of physical inactivity was $1.8 billion and the cost associated with obesity was $1.6 billion (Katzmarzyk and Janssen, 2003). The current estimates for 2009 are substantially higher. There are several reasons for the higher economic estimates attributed to physical inactivity and obesity in 2009 versus 2001 in Ontario. For physical inactivity, the population prevalence has declined slightly (53.9% in 2001 versus 49.3% in 2009); thus the increase in the associated economic costs (from $1.8 billion to $3.4 billion) are largely a function of the overall increases in medical expenditures and associated indirect costs between 2001 and 2009 in Ontario.

The estimate of the economic costs attributable to obesity increased much more than the costs associated with physical inactivity. The increase in the obesity costs are a function of the overall increase in medical costs between 2001 and 2009, and the change in the prevalence of obesity. The estimates for 2001 were based on the self-reported prevalence of obesity available at the time (15.5%)(Katzmarzyk and Janssen, 2003); whereas the 2009 costs are based on a estimate of the true prevalence of obesity (25.4%). The change in the prevalence of obesity resulted in a greater estimate of the PAR, which translates into an increase in the attributable costs.

The medical costs attributable to physical inactivity and obesity will continue to increase in Ontario in proportion to the increase in general medical expenditures unless the prevalences are reduced through prevention and treatment efforts. The impact of the change in physical inactivity prevalence observed between 2001 and 2009 (53.4% to 49.3%) is presented in Figure 2a, controlling for inflation by presenting all results in 2009 dollars. The estimated reduction in economic costs attributed to physical inactivity was

![Figure 2: Comparison of the economic costs of A) physical inactivity and B) obesity in Ontario in 2001 and 2009. Values have been standardized to 2009 dollars.](image)
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$244.4 million ($74.3 million direct and $170.2 million indirect). Thus, the proportion of the total medical costs associated with physical inactivity have been reduced, but this cost saving has been overwhelmed by the overall increase in medical expenditures between 2001 and 2009.

The impact of the change in obesity prevalence observed between 2001 and 2009 is presented in Figure 2b, controlling for inflation by presenting all results in 2009 dollars. The prevalence of self-reported obesity in 2001 was 15.5%, which was adjusted to an estimate of the true prevalence (22.6%) by applying the same correction factor as to the 2009 data (1.4593). The estimated increase in economic costs attributed to obesity due to the increase in prevalence to 25.4% was $360.6 million ($122.0 million direct and $238.6 million indirect), irrespective of the increase in overall medical expenditures.

The medical costs in Ontario are roughly 39.3% of the national estimates (Canadian Institute for Health Information, 2010). Thus, by extrapolating the Ontario data one could estimate that the national costs attributable to inactivity and obesity in 2009 were roughly $8.6 billion ($2.60 billion direct, $5.95 billion indirect) and $11.4 billion ($4.07 billion direct, $7.30 billion indirect), respectively. A recently published study has also produced national estimates of the costs of obesity for Canada for the year 2006 using a prevalence-based approach (Anis et al., 2010). These authors estimated that the direct medical costs associated with obesity were approximately $3.9 billion, which is similar but slightly lower than the estimate presented here for 2009 ($4.07 billion). These comparisons add to the face validity of the results obtained for Ontario.

Estimates of the economic costs of physical activity have been generated for some other provinces using a similar methodology. For example, it has been estimated that the economic cost of physical inactivity was $354 million annually ($107 million direct and $247 million indirect) for Nova Scotia in 1998 (Colman, 2002), and $573 million annually ($211 million direct and $362 million indirect) in British Columbia in 1998 (Colman and Walker, 2004). The degree to which these costs have changed in the past decade are not known, but based on the results from Ontario, these costs are likely also substantially higher now than in 1998.

This study has several strengths and weaknesses that deserve discussion. The use of summary RR estimates from a meta-analysis rather than the results of single cohort study is a marked strength of this research. Further, the use of robust population-level estimates of the prevalence of physical inactivity and obesity from the Canadian Community Health Survey is also a strength of this study. However, the use of a prevalence-based methodology that relies on PAR% calculations yields theoretical estimates of the effects on economic costs. In order to better establish the true cost-benefit relationships for physical inactivity and obesity intervention strategies, future research studies should employ incidence-based and linkage-based study designs.

Conclusions

The prevalences of physical inactivity (<1.5 kcal/kg·day⁻¹ of leisure time energy expenditure) and obesity (body mass index ≥30 kg/m²) among Ontario adults for 2009 are 49.3% and 25.4%,
respectively. The economic burden of physical inactivity was $3.4 billion ($1.02 billion in direct costs and $2.34 billion in indirect costs) while the burden associated with obesity was $4.5 billion ($1.60 billion in direct costs and $2.87 billion in indirect costs). These estimates are a direct reflection of the reported prevalences of physical inactivity and obesity, and the established relationships between physical inactivity, obesity and chronic diseases. Given that there is little evidence for temporal changes in the relationships between physical activity, obesity and chronic diseases, the main strategy for reducing the associated economic burden is to reduce the prevalences. A realization of this strategy will take concerted public health prevention efforts from several jurisdictions.

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Author Qualifications
The author’s qualifications are: Peter T. Katzmarzyk, MSc, PhD, FACSM

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