

bfu-report no. 64

Physical Activity Promotion and Injury Prevention



Authors:
Eva Martin-Diener, Othmar Brügger, Brian Martin

Berne 2010



University of
Zurich^{UZH}



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Relationship in sports and other forms of physical activity

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For ease of reading, the consistent use of masculine and feminine terminology has been dispensed with.
Slight differences are possible in table totals due to rounding up/down.
We trust that this will not inconvenience readers.

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Foreword

Nothing can be more important than our health. An optimal amount of physical activity is an important requirement for maintaining health. Physical activities encompass an unlimited range of possibilities – of which sport is just one specific example. Nevertheless, a large proportion of the Swiss population does not do enough physical activity. A number of national institutes are thus involved with programmes for health promotion, with the goal of encouraging inactive people to undertake more physical activity. However, every form of physical activity brings with it a certain potential for injury. The promotion of exercise as a way of helping to maintain or improve health should not result in an increase in the number of accidents that occur; rather, it should, in the best case, minimise the risk of injury.

Although in recent years there has been an increase in research carried out on this topic, until now an overview of the knowledge gained had never been available in a clear format, nor could the key findings be found in a concise summary. This work has now been achieved by the Institute for Social and Preventive Medicine (ISPM) at the University of Zurich, on behalf of bfu – Swiss Council for Accident Prevention.

The report is published in English so that the elucidated knowledge can be accessed by as many people as possible, and so that there can be discussion about the findings also on an international level.

In summary, the following can be said: Yes, by promoting exercise accidents can be prevented per se, but it is dependant on how such exercise programmes are designed.

bfu would like to thank the ISPM of the University of Zurich for the very good cooperation. We would also like to thank all the other specialists who contributed to the success of this project.

bfu



Brigitte Buhmann
Managing Director

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I. Summary / Zusammenfassung / Résumé / Riassunto

1. Injury Prevention in Sports and in the Promotion of Physical Activity

1.1 Introduction

The positive effects of regular physical activity on health and well-being are well recognised, the evidence has been updated in 2008 by the US Physical Activity Guidelines Advisory Committee. Nevertheless, levels of physical activity are still low in Switzerland but seem to be on the rise: According to the Swiss Health Surveys the proportion of sufficiently active adults increased from 36% in 2002 to 41% in 2007.

Accidents resulting in injuries or even death are a huge public health problem. Even though there have been great efforts over decades to prevent injuries almost one million non-occupational accidents resulting in injury or death are counted every year in Switzerland. 100,000 individuals are injured in road accidents, 300,000 during sports activities and 600,000 in the household or during leisure time activities other than sports. Some 2,000 people are killed each year through a non-occupational accident.

Sometimes, and in particular in the perception of the public, a direct causal link is established between rising levels of physical activity and increases in sports injuries. On the other hand, it is sometimes stated that more physical activity will lead to a reduction of injuries. Such diverse views illustrate that the relationship between physical activity behaviour and the burden of injury in the

population is complex. A broad perspective on this issue cannot only consider the relationship between physical activity and sports-related injuries, but injuries from all causes. It is possible for example, that active people suffer from fewer injuries in other contexts because of their enhanced fitness. The purpose of this report is to give an overview of the scientific literature regarding this relationship for different age groups of the general population. The key questions are, firstly, whether overall an active population will have more or less injuries than an inactive population, and secondly, under which circumstances physical activity promotion as such can prevent injuries.

1.2 Methods

The report of the US Physical Activity Guidelines Advisory Committee served as the starting point, particularly the sections on functional health (falls and fall-related injuries in older adults) and on adverse events (musculoskeletal injuries). In a second step literature data bases were searched for reviews and single papers that had been published between 2007 and 2009, and for earlier European publications on the topics discussed in the Advisory Committee's report. In a third step, the reference lists were completed by reports and other forms of grey literature from Switzerland. In a fourth and final step, selected institutions and experts from other countries were asked to comment on a first version of the report.

1.3 Results

Usually studies do not distinguish between traumatic injuries and injuries resulting from overuse. Therefore, studies that made no distinction were included in this literature overview while studies that explicitly investigated overuse injuries were not. The overall question investigating the association between physical activity behaviour and all-cause injury risk is hardly ever addressed as such. But a variety of studies could be identified that investigated more specific research questions differing remarkably over the life span.

1.3.1 Working-age population

A few observational studies with cross-sectional data analysis addressing the association between habitual physical activity and activity-related injuries as well as all-cause injuries could be identified. A small number of Swiss population surveys provided further insights. No studies among middle age adults with prospective longitudinal designs were found.

Evidence in brief:

- There is good evidence for large differences of injury risks within specific sports or activities.
- There is some consistent evidence that higher levels of physical activity, in particular regarding intensity, are related to higher numbers of activity-related injuries in the general population. There are some suggestions that activity-related injuries could be more severe among those who are not active on a regular basis. There are indications from some studies suggesting that higher levels of physical activity are not necessarily related to increased risks of all-cause injuries.

- There is some evidence from exercise intervention studies suggesting that frequency, duration, intensity and type of activity all contribute to the risk of physical activity-related injuries, and that moderate intensity physical activity appears to have low (but not precisely measured) injury rates.

1.3.2 Older adults

Among older adults, falls and osteoporotic fractures are the main outcomes of interest. The US Physical Activity Guidelines Advisory Committee included eight systematic reviews or meta-analysis of intervention trials investigating the effects of physical activity programmes on the risk of falls in its report. The evidence regarding the risk of osteoporotic fractures, mainly of the hip, is based on prospective cohort and case-control studies. A large randomised controlled trial is still missing.

Evidence in brief:

- In older adults at increased risk of falling there is good evidence that participation in physical activity programmes can reduce the risk of falls from any cause. The evidence is strongest for physical activity interventions that include muscle strengthening, balance training and aerobic activities, especially walking. In addition, there is growing evidence that Tai Chi exercises provide benefit.
- There is moderate to good evidence that in older adults, higher levels of physical activity are associated with a reduced risk of osteoporotic fractures, in particular of the hip. There is some evidence that decreases in leisure time physical activity are associated with an increase of the hip fracture risk after a relatively short period of time. The evidence that self-selected increases

in leisure time physical activity are associated with a decrease of the hip fracture risk is slightly less pronounced.

- There is moderate evidence suggesting that also population-based fall-prevention programmes can reduce the risk of fall-related injuries from any cause.

1.3.3 Children and adolescents

Apart from a few longitudinal studies, cross-sectional studies attempting to identify risk factors for injuries dominate the literature for these age groups. The exposure is usually a measure of sports participation or vigorous activity. Given this predominantly pathogenetic perspective of the relation between physical activity and injury risk, other physical activity behaviours (e. g. moderate intensity activities) that might not be associated with injury risk or could even protect from injuries are rarely investigated or the respective findings are not reported.

Evidence in brief:

- Starting in preadolescence, injury risk increases until about 15 years of age. Boys have more injuries than girls; however, if exposure to physical activity is considered this gender difference becomes less clear.
- There is consistent evidence that participation in sports or vigorous activity is strongly associated with an increased risk of sports-related injuries, and there is some evidence for a dose-response-relationship in this respect.
- There is some evidence that participation in sports or vigorous activity seems to be associated with an increased risk of fractures and injuries from all causes.
- There is limited evidence from few studies

suggesting that non-sports activities are *not* associated with injuries from all causes and that non-vigorous activities could be protective of fractures.

1.3.4 Specific populations

Injuries among **athletes in sports** are common and previous injury is a strong predictor of injury incidence. Interventions to reduce injury risk in athletes are thus very important. Studies with **army trainees** can serve as a model to illustrate different aspects of the relationship between physical activity and the risk of injury because both levels of physical activity and overall injury risk are high. As already shown for fall prevention in elderly people, there is evidence that specific training programmes can reduce the risk of injury among individuals who need to perform near or at the limits of their capacities. In all these cases, targeted interventions seem to be most effective.

Evidence in brief:

- Specific training interventions have been shown to be effective in reducing sport injuries in athletes. The strength of the evidence for effectiveness depends on the sport discipline, the target group, the elements of the intervention and the injury outcome of interest.
- Army training is characterised by high levels of physical activity, by high injury risks and by sometimes considerable differences in previous activity and fitness levels. There is consistent evidence that injuries are more frequent among trainees with low fitness. A number of studies have shown that injury incidence can be reduced by specific conditioning programmes.
- It is not yet clear to what extent these findings can be generalised to larger population groups.

1.3.5 National guidelines and recommendations in other countries

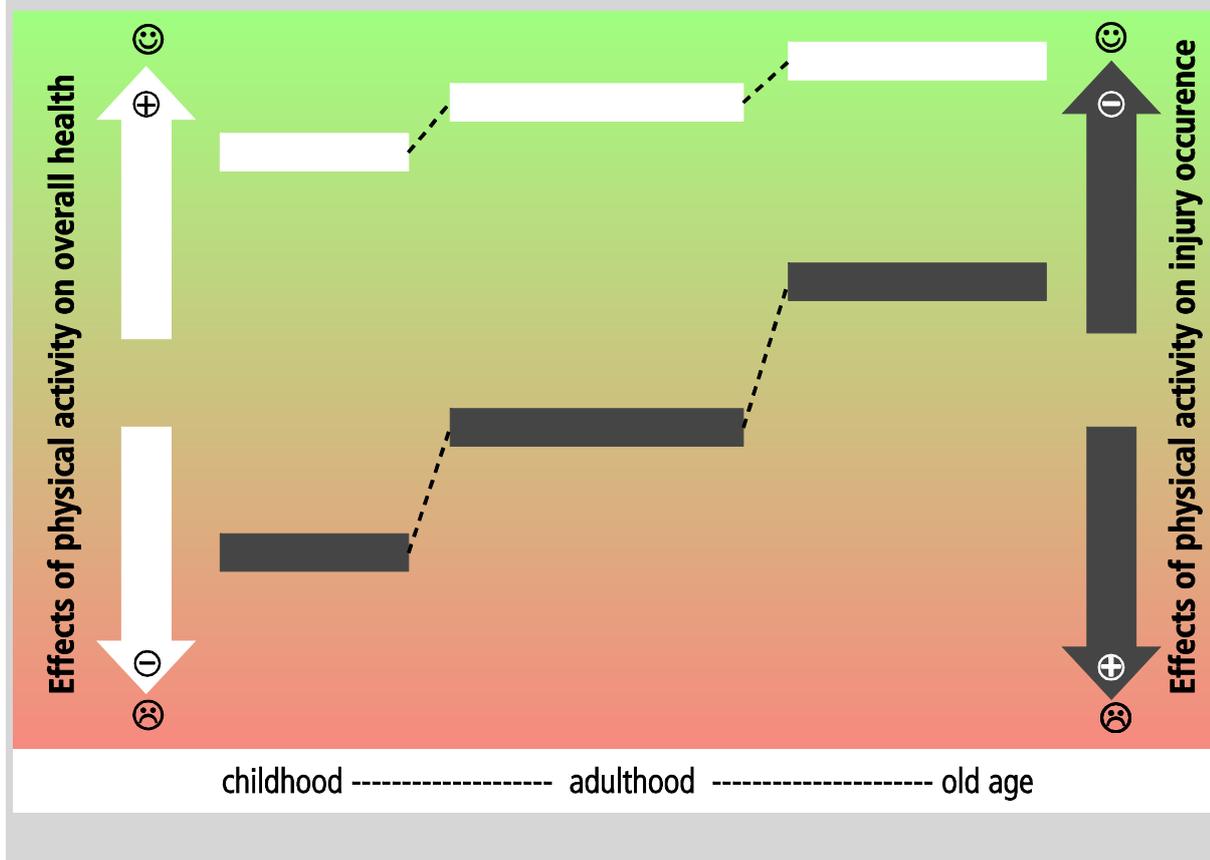
Experts in the field of physical activity promotion and injury prevention from the EMGO Institute of the Free University of Amsterdam (Netherlands) and the Centres for Disease Control CDC in Atlanta (USA) provided information about the situation in their country and commented on the report. In the US, specific recommendations for safe physical activity have been included in the national physical activity guidelines issued in 2008. The recommendations formulated in this report are in line with the US guidelines. The Netherlands don't have specific policies, however, the experts agree with the recommendations of the report.

1.4 Discussion and conclusions

1.4.1 Synthesis

The reviews and studies identified for this report provide some insights into the complex relation between physical activity promotion and injury prevention in the general population. Figure 1 attempts to give a synthesis of the evidence on the association between physical activity and overall health over the life course on the one hand and the possible relation between physical activity and the risk of injuries from childhood to old age on the other hand. There is strong evidence that physical activity is good for health in all age groups. Promoting physical activity in older adults also reduces the risk of injuries. In adults at

Figure 1
Synthesis of the association between physical activity behaviour and health and the possible relation between physical activity behaviour and injury risk over the life course



working age, higher levels of activity seem to be related to higher numbers of activity-related injuries but not necessarily to more injuries from all causes. In children and adolescents, engagement in sports or vigorous activities is associated with higher levels of injuries from any cause. Summing up, there is some evidence for the direction of the association between physical activity behaviour and injury risk in different age groups, however, the strength of these associations and also the age periods at which the associations change in magnitude and direction are still to be explored.

Overall, this research area still seems to be in its infancy. Apart from studies in older adults, there are only very few papers investigating the relation between physical activity promotion and injury prevention from a salutogenetic perspective. The majority of studies aim at identifying risk factors for injuries. Consequently, physical activity related behavioural factors that could prevent injuries are rarely investigated and if no associations are found – i. e. the behaviour is not a risk for injury – it is likely that these findings are not reported. The indicators and methods to assess exposure and outcomes are not standardised, making it difficult to compare studies. The number of studies with a prospective design is limited and cross-sectional studies assessing the occurrence of injuries retrospectively have methodological limitations. With a retrospective assessment of injury rates it can not be excluded that an injury affected the physical activity habits and that therefore the causal pathway of the association between physical activity and injury is reversed.

1.4.2 Recommendations for implementation

Despite its limitations, the current state of evidence allows the following specific recommendations for implementation and practice:

- **Children and young people: Link up physical activity promotion and accident prevention.** The promotion of physical activity and sport in children is an important public health issue. To avoid an increase in injuries, it is important to accompany physical activity promotion with all measures of accident prevention in this age group.
- **Adults: Support the right choices in physical activity promotion.** Adults should be encouraged to maintain and increase their sport and physical activity behaviour. They should be supported in taking up activities appropriate for their age and their individual level of fitness and experience and exercise programmes should be introduced gradually.
- **Elderly people: Physical activity promotion is accident prevention.** Maintaining and increasing physical activity in elderly people helps to keep them independent and reduce falls and fractures. Multidimensional training programmes seem to be most effective, and the general measures of accident prevention should be observed.

1.4.3 Recommendations for research

The report of the Physical Activity Advisory Committee has identified a number of research needs regarding physical activity and adverse events: Firstly, the question whether active and inactive individuals are at equal risk for injuries from any cause should be addressed. Furthermore, research needs to concentrate on what the appropriate starting doses of activity and the sizes of increase are in order to prevent activity-related injuries among those who become more active. In the prevention of falls among older adults, it is not yet clear which programmes are most suitable for which group and whether there is a threshold or dose-response effect of physical activity in this respect. Furthermore, a sufficiently powered randomised controlled trial is still needed to assess the effects of physical activity on fractures as an endpoint. Overall, it seems most important to further quantify the relationship between physical activity and injury risk as well as the effects of interventions, to investigate the specificities and differences between age groups, and to verify the generalisability of experiences from specific groups such as athletes or military trainees to the general population. The following specific recommendations can be derived:

- **Make most of existing datasets and improve the methods.** There are indications that a number of surveys and studies have assessed information on exposure and outcomes but that the associations of interest have not been investigated or published. Progress in the assessment methods for both physical activity behaviour and injury occurrence will lead to new insights.
- **Conduct population studies with prospective designs.** Population studies with pro-

spective designs and adequate methodology are needed among children and adults.

- **Assess the effect of physical activity promotion interventions on injury risk.**

There are some physical activity promotion interventions targeting adults that have a high potential for both effectiveness and large scale implementation, such as community interventions and physical activity promotion through primary care or at the work site; their effects on injury risk should be assessed. Furthermore, the question whether interventions to improve general fitness and in particular coordination or motor skills in young children reduce the number of injuries should be addressed with well designed intervention studies.

A number of important research questions are still unanswered concerning the relationship between physical activity and injury risk. However, there are strong indications already that physical activity promotion and accident prevention are allies and not opponents. The optimal effect on public health and the optimal use of resources will be attained by adhering to the practice recommendations outlined above. The research recommendations will allow to strengthen the body of evidence and to contribute to further progress in the practice of physical activity promotion and accident prevention.

2. Bewegungsförderung und Unfallprävention

2.1 Einleitung

Die positiven Effekte von regelmässiger Bewegung auf die Gesundheit sind breit anerkannt, die Erkenntnisse wurden 2008 durch das US Physical Activity Guidelines Advisory Committee aktualisiert und bestätigt. Trotzdem ist in der Schweiz das Niveau des Bewegungsverhaltens immer noch tief, wobei es sich zu verbessern scheint: Gemäss den Schweizerischen Gesundheitsbefragungen hat sich der Anteil genügend körperlich aktiver Erwachsener von 2002 bis 2007 von 36 % auf 41 % verbessert.

Unfälle und Verletzungen stellen ein Public-Health-Problem dar. Trotz grossen, jahrzehntelangen Anstrengungen in der Unfallprävention ereignet sich in der Schweiz jedes Jahr etwa eine Million Nichtberufsunfälle. 100 000 Personen werden im Strassenverkehr verletzt, 300 000 beim Sport und 600 000 im häuslichen Umfeld oder in der Freizeit ohne Sportaktivitäten. Und etwa 2000 Personen sterben jedes Jahr an den Folgen eines Nichtberufsunfalls.

Manchmal wird in der öffentlichen Wahrnehmung eine direkte kausale Verbindung zwischen vermehrter Bewegung und Zunahme von Sportverletzungen hergestellt. Umgekehrt wird gesagt, dass mehr Bewegung zu weniger Unfällen führt. Solche widersprüchlichen Sichtweisen zeigen, dass die Zusammenhänge zwischen Bewegungsverhalten der Bevölkerung und Unfallgeschehen komplex sind. Eine breite Sicht auf dieses Themenfeld darf nun nicht nur die Zusammenhänge zwischen Bewegungsverhalten und Sportunfällen berücksichtigen,

sondern muss auch Unfälle und Verletzungen in anderen Bereichen (Strassenverkehr, Haus, Freizeit) einbeziehen. Es ist zum Beispiel denkbar, dass aktive Personen weniger Verletzungen in anderen Bereichen erleiden, weil ihre Fitness besser ist. Das Ziel dieses Berichts ist, einen Überblick über die wissenschaftliche Literatur zu diesen Zusammenhängen für verschiedene Altersgruppen der Bevölkerung zu geben. Die Hauptfragestellungen waren, ob eine aktive Bevölkerung insgesamt mehr Verletzungen hat als eine inaktive und ob Bewegungsförderung unter gewissen Bedingungen per se unfallpräventiv wirken kann.

2.2 Methode

Der Bericht des US Physical Activity Guidelines Advisory Committee bildete den Ausgangspunkt, insbesondere die Kapitel zur funktionellen Gesundheit (Stürze und sturzbedingte Verletzungen bei älteren Personen) und zu unerwünschten Effekten von Bewegung (Verletzungen des Bewegungsapparats). In einem zweiten Schritt wurde in den Literaturdatenbasen nach Reviews und Studien gesucht, die zwischen 2007 und 2009 publiziert wurden sowie nach früheren europäischen Studien. Im dritten Schritt wurden Berichte und andere Formen grauer Literatur aus der Schweiz aufgenommen. Als vierter und letzter Schritt wurden ausgewählte Experten und Institutionen aus anderen Ländern eingeladen, eine erste Fassung des Berichts zu kommentieren.

2.3 Resultate

In der Literatur wird oft nicht unterschieden zwischen traumatischen Verletzungen und Verletzungen durch Überbelastung. Aus diesem Grund wurden Studien, die keine Unterscheidung

machten, in die Übersicht aufgenommen, hingegen wurden Artikel, die sich explizit mit Überlastungsverletzungen befassen, nicht aufgenommen. Die Hauptfragestellung nach dem Zusammenhang zwischen Bewegungsverhalten und dem gesamten Verletzungsrisiko wird kaum je besprochen. Hingegen wurde eine Reihe von Studien identifiziert, die für die verschiedenen Altersgruppen spezifische Fragestellungen untersuchten.

2.3.1 Erwachsene im Erwerbsalter

Es wurden einige wenige beobachtende Studien mit querschnittlicher Datenanalyse identifiziert, die die Zusammenhänge zwischen dem habituellen Bewegungsverhalten und von Sport- und Bewegungsverletzungen resp. allen Arten von Verletzungen untersuchten. Zudem trug eine kleine Zahl von Schweizer Surveys zur Vertiefung der Erkenntnisse bei. Studien mit Erwachsenen im mittleren Alter mit längsschnittlichem prospektivem Design wurden keine gefunden.

Die wichtigsten Erkenntnisse:

- Es gibt gute Evidenz, dass das Verletzungsrisiko bei einzelnen Sportarten oder Aktivitäten stark variieren kann.
- Die Evidenz ist konsistent, dass ein höheres Bewegungsniveau, insbesondere bezüglich Intensität, in der Bevölkerung mit mehr Sport- und Bewegungsverletzungen verbunden ist. Es gibt erste Hinweise darauf, dass bei Personen, die nicht regelmässig aktiv sind, Verletzungen durch Bewegung und Sport schwerer sein könnten. Ferner gibt es Hinweise aus wenigen Studien, dass das globale Verletzungsrisiko bei aktiven Personen nicht unbedingt höher ist als bei inaktiven.
- Schliesslich gibt es Hinweise aus einzelnen Interventionsstudien, dass bei der Förderung von

Bewegung und Sport Häufigkeit, Dauer, hohe Intensität und gewisse Bewegungsarten das Risiko von Verletzungen erhöhen können. Die Förderung von Bewegung mit geringerer Intensität dürfte zu einer kleinen Risikoerhöhung führen – auch wenn diese noch nicht genau bestimmt werden konnte.

2.3.2 Ältere Menschen

Stürze und osteoporotische Frakturen sind die am meisten untersuchten Gesundheitseffekte (Outcomes) bei älteren Menschen. Der Bericht des US Physical Activity Guidelines Advisory Committee berücksichtigte acht systematische Reviews resp. Meta-Analysen von Interventionsstudien, die die Auswirkungen von Bewegungsprogrammen auf das Sturzrisiko untersuchten. Die Evidenz bezüglich osteoporotischen Frakturen, insbesondere des Schenkelhalses, basiert auf prospektiven Kohorten- und Case-Control-Studien. Eine grosse randomisierte Studie zu dieser Frage fehlt noch.

Die wichtigsten Erkenntnisse:

- Für Personen mit erhöhtem Sturzrisiko gibt es klare Evidenz, dass dieses durch Bewegungsprogramme gesenkt werden kann. Am besten gesichert ist die Evidenz für Programme, die Kraft- und Balancetraining sowie Elemente aus dem Ausdauerbereich, insbesondere Gehen, beinhalten. Ausserdem nimmt die Evidenz zu, dass Tai Chi positive Auswirkungen auf das Sturzrisiko hat.
- Es gibt mittlere bis gute Evidenz, dass bei älteren Erwachsenen ein höheres Bewegungsniveau verbunden ist mit einem geringeren Risiko osteoporotischer Frakturen, insbesondere des Schenkelhalses. Es gibt einige Hinweise darauf, dass eine Abnahme des Bewegungsverhaltens

in der Freizeit relativ schnell zu einer Zunahme des Frakturrisikos führt. Weniger gut belegt ist der umgekehrte Mechanismus, also dass eine selbstgewählte Steigerung des Bewegungsverhaltens zu einer Abnahme des Frakturrisikos führt.

- Es gibt moderate Evidenz, dass bevölkerungsweite Präventionsprogramme das Risiko von Verletzungen durch Stürze senken können.

2.3.3 Kinder und Jugendliche

Abgesehen von wenigen Längsschnittstudien wird die Literatur für diese Altersgruppen von Querschnittsuntersuchungen zur Identifikation von Risikofaktoren für Verletzungen dominiert. Meistens wird «Bewegung» als Teilnahme an sportlichen oder intensiven Aktivitäten definiert. Da diese eher pathogenetische Sichtweise des Zusammenhangs zwischen Bewegung und Verletzungsrisiko vorherrscht, werden andere Formen des Bewegungsverhaltens (z. B. Bewegung mit mässiger Intensität), die nicht unbedingt mit dem Verletzungsrisiko zusammenhängen müssen oder gar vor Verletzungen schützen könnten, kaum untersucht oder die entsprechenden Resultate werden nicht publiziert.

Die wichtigsten Erkenntnisse:

- Von der Präadoleszenz bis etwa zum 15. Altersjahr steigt das Verletzungsrisiko an. Knaben haben mehr Verletzungen als Mädchen; berücksichtigt man allerdings die Exposition bezüglich Bewegung, wird dieser Geschlechtsunterschied weniger klar.
- Die Evidenz ist konsistent, dass Sporttreiben und intensive Aktivitäten stark mit einem erhöhten Risiko für Sportverletzungen zusammenhängen. Es gibt Hinweise auf eine diesbe-

zügliche Dosis-Wirkungs-Beziehung.

- Ebenso gibt es deutliche Hinweise darauf, dass Sporttreiben und intensive Aktivitäten auch mit einem erhöhten Risiko von Knochenbrüchen sowie einem erhöhten globalen Verletzungsrisiko verbunden sind.
- Nur wenige Studien untersuchten den Zusammenhang zwischen nichtsportlichen Aktivitäten und dem globalen Verletzungsrisiko: Es gibt Hinweise darauf, dass hier kaum ein Zusammenhang besteht. Ferner zeigte sich, dass mässig intensive Aktivitäten vor Knochenbrüchen schützen können.

2.3.4 Spezifische Gruppen

Verletzungen bei **Athleten** sind häufig und frühere Verletzungen ein starker Risikofaktor für erneute Verletzungen. Interventionen zur Reduktion des Verletzungsrisikos bei Athleten sind deshalb sehr wichtig. Studien mit **Rekruten der Armee** können als Modell dienen, um verschiedene Aspekte des Zusammenhangs zwischen Bewegung und Verletzungsrisiko zu illustrieren, weil sowohl das Bewegungsniveau als auch das Verletzungsrisiko im Militär hoch sind. Wie bereits in der Sturzprävention mit älteren Menschen beschrieben, können bei Personen, die im Bereich der Grenze ihrer Leistungsfähigkeit gefordert sind, spezifische Trainingsprogramme das Verletzungsrisiko senken. In allen Fällen scheinen gezielte Interventionen am Erfolg versprechendsten zu sein.

Die wichtigsten Erkenntnisse:

- Spezifische Trainingsinterventionen können das Verletzungsrisiko bei Athleten reduzieren. Das Ausmass der Evidenz hängt ab von der Sportdisziplin, der Zielgruppe, den Elementen der Intervention und der untersuchten Verletzungsart.

- Die Ausbildung in der Armee ist charakterisiert durch hohe Anforderungen im Bewegungsbe- reich, hohes Verletzungsrisiko und manchmal beträchtliche Unterschiede bezüglich Bewe- gungsverhalten und Fitness vor der Ausbildung. Die Evidenz ist konsistent, dass das Verletzungs- risiko bei Militärangehörigen mit tiefer Fitness höher ist. Eine Anzahl Studien hat gezeigt, dass die Inzidenz von Verletzungen durch spezifische Vorbereitungsprogramme reduziert werden kann.
- Es ist noch nicht klar, wie weit diese Erkennt- nisse für die breite Bevölkerung verallgemeinert werden können.

2.3.5 Nationale Richtlinien und Empfeh- lungen in anderen Ländern

Experten auf dem Gebiet der Bewegungsförderung und Unfallprävention des EMGO Instituts der freien Universität Amsterdam (Niederlande) und der Centres for Disease Control CDC in Atlanta (USA) wurden gebeten, entsprechende Empfehlungen und Policies aus ihren Ländern aufzuzeigen und den vorliegenden Bericht zu kommentieren. In den USA wurden spezifische Empfehlungen im Sinne der Unfallprävention in die nationalen Bewegungsempfehlungen von 2008 aufgenommen; die in diesem Bericht formulierten Empfehlungen gehen in die gleiche Richtung wie diejenigen in den USA. In den Niederlanden gibt es keine spezifischen Policies, aber die Experten heissen die im Bericht formulierten Empfehlungen und Folgerungen gut.

2.4 Diskussion und Folgerungen

2.4.1 Synthese

Die für diesen Bericht identifizierten Reviews und Studien erlauben einen gewissen Einblick in die

komplexen Zusammenhänge zwischen Bewe- gungsförderung und Unfallprävention. Die Abbildung 1 gibt einen schematischen Gesamt- überblick von der Kindheit bis ins höhere Alter über die Zusammenhänge zwischen Bewegung und Gesundheit einerseits und die möglichen Zu- sammenhänge zwischen Bewegung und Unfallhäu- figkeit andererseits. Die positiven Wirkungen von Bewegung auf die Gesundheit sind für alle Alters- gruppen erwiesen. Bewegungsförderung bei älteren Menschen reduziert auch das Unfallrisiko. Bei Erwachsenen im Erwerbsalter scheint Bewe- gung mit mehr bewegungsbezogenen Verletzun- gen assoziiert zu sein, aber nicht unbedingt mit mehr Verletzungen insgesamt. Kinder und Jugend- liche, die viel Sport treiben und intensiv aktiv sind, haben ein höheres globales Verletzungsrisiko. Ins- gesamt weiss man einiges darüber, in welche Rich- tung die Zusammenhänge zwischen Bewegung und Unfallgeschehen in verschiedenen Alters- gruppen gehen. Hingegen braucht es noch For- schungsanstrengungen, um über deren Ausmass sowie die Altersbereiche, in denen sich Zusam- menhänge bezüglich Ausmass und Richtung än- dern, gesicherte Aussagen machen zu können.

Insgesamt steckt dieses Forschungsgebiet noch in den Kinderschuhen. Abgesehen von Studien mit älteren Erwachsenen gibt es nur wenige Unters- uchungen, die den Zusammenhang zwischen Bewe- gungsförderung und Unfallprävention aus einer salutogenetischen Perspektive konzipieren. Die Mehrheit der Studien hat zum Ziel, Risikofaktoren für Verletzungen zu identifizieren. Aus diesem Grund werden Aspekte des Bewegungsverhaltens, das vor Verletzungen schützen könnte, kaum je untersucht, und falls keine Zusammenhänge ge- funden werden, das heisst, der Aspekt des Bewe- gungsverhaltens kein Risikofaktor ist, werden

solche Resultate wohl oft nicht publiziert. Die Indikatoren und Methoden zur Messung der Exposition und der Outcomes sind nicht standardisiert, was den Vergleich von Studien oft schwierig macht. Die Anzahl prospektiver Studien ist begrenzt und querschnittlich angelegte Studien, die das Unfallgeschehen retrospektiv erfassen, sind mit methodischen Limitationen behaftet. So kann nicht ausgeschlossen werden, dass eine Verletzung später das Bewegungsverhalten beeinflusst und die Kausalität der Zusammenhänge zwischen Bewegungsverhalten und Verletzungsrisiko deshalb umgekehrt ist.

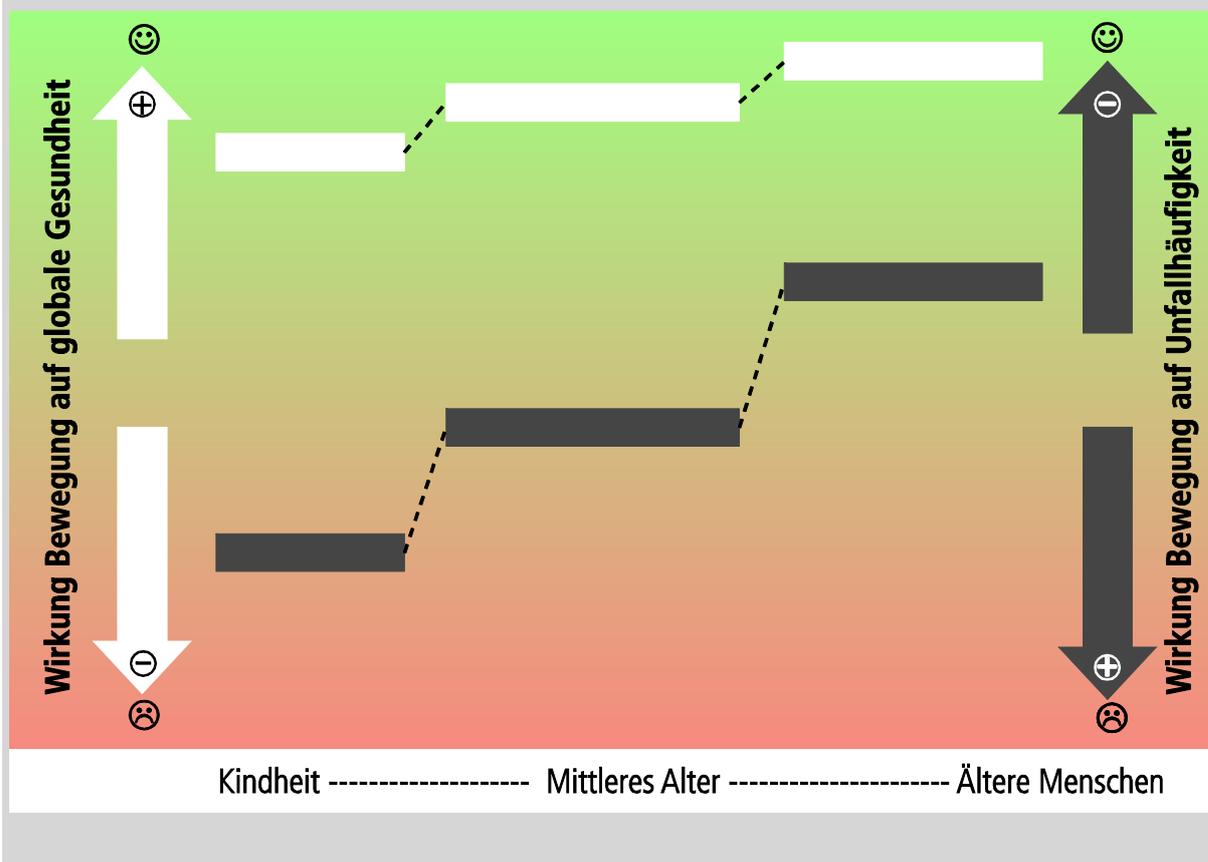
2.4.2 Empfehlungen für die Umsetzung

Trotz einiger Limitationen erlaubt es der gegenwärtige Stand des Wissens, spezifische Empfehlun-

gen für die Umsetzung zu formulieren:

- **Kinder und junge Menschen: Bewegungsförderung mit Massnahmen der Unfallprävention verknüpfen.** Die Förderung von Bewegung und Sport bei Kindern ist eine wichtige Aufgabe von Public Health. Um in diesem Zusammenhang ein Ansteigen der Unfallzahlen zu vermeiden, ist es wichtig, Bewegungsförderung in diesem Alter mit allen Massnahmen der Unfallprävention zu begleiten.
- **Erwachsene: In der Bewegungsförderung die richtige Wahl unterstützen.** Erwachsene sollten ermutigt werden, ihr Bewegungs- und Sportverhalten beizubehalten oder zu verbessern. Sie sollten darin unterstützt werden, Aktivitäten zu wählen, die für ihr Alter und ihre individuellen Voraussetzungen bezüglich Fitness und Erfah-

Abbildung 1
Zusammenhänge zwischen Bewegung und Gesundheit sowie mögliche Zusammenhänge zwischen Bewegung und Verletzungen im Lebensverlauf: Eine Synthese



rungen geeignet sind. Belastungssteigerungen sollten angemessen erfolgen.

- **Ältere Menschen: Bewegungsförderung wird per se Unfallprävention.** Die Aufrechterhaltung oder Verbesserung des Bewegungsverhaltens hilft älteren Menschen, ihre Unabhängigkeit zu bewahren und reduziert das Sturz- und Frakturrisiko. Multidimensionale Trainingsprogramme scheinen am wirksamsten zu sein, wobei die allgemeinen Massnahmen der Unfallprävention berücksichtigt werden sollten.

2.4.3 Empfehlungen für die Forschung

Der Bericht des Physical Activity Advisory Committee identifizierte eine Anzahl Forschungsfragen aus dem Themengebiet der unerwünschten Wirkungen körperlicher Aktivität. Erstens sollte die Frage, ob aktive und inaktive Menschen das gleiche globale Unfallrisiko haben, untersucht werden. Ferner sollte erforscht werden, welche Bewegungsdosis für Einsteiger angemessen ist und wie diese gesteigert werden kann, ohne dass das Verletzungsrisiko zunimmt. In der Sturzprävention bei älteren Menschen ist noch nicht klar, welches die besten Programme für welche Gruppen sind und ob es bezüglich Wirksamkeit eine minimale Schwelle oder eine Dosis-Wirkungs-Beziehung des Bewegungsverhaltens gibt. Ausserdem fehlt immer noch eine genügend grosse randomisierte kontrollierte Studie zur Bestimmung der Wirkung von Interventionen auf das Frakturrisiko. Insgesamt wird es wichtig sein, die Zusammenhänge zwischen Bewegungsverhalten und Verletzungsrisiko sowie die Effekte von Interventionen weiter zu quantifizieren, für die verschiedenen Altersgruppen die spezifischen Eigenheiten und Unterschiede herauszuarbeiten und die Generalisierbarkeit der Erkenntnisse aus spezifischen Gruppen wie Athleten oder Armeean-

gehörigen zu verifizieren. Die folgenden spezifischen Empfehlungen können formuliert werden:

- **Bestehende Datensets nutzen und Methoden verbessern.** Es gibt Hinweise darauf, dass eine Reihe von Studien und Surveys zwar Informationen zu Exposition und Outcomes erhoben haben, dass aber Zusammenhänge, die für diesen Bericht von Interesse sind, nicht untersucht oder nicht publiziert wurden. Fortschritte bei der Verbesserung der Methoden zur Messung des Bewegungsverhaltens sowie des Verletzungsrisikos werden neue Erkenntnisse ermöglichen.
- **Bevölkerungsbasierte Studien mit prospektivem Design durchführen.** Für Erkenntnisse zu Kindern und Erwachsenen sind Bevölkerungsstudien mit prospektivem Design und adäquater Methodologie nötig.
- **Die Auswirkungen von Massnahmen der Bewegungsförderung auf das Verletzungsrisiko untersuchen.** Es gibt Interventionen zur Bewegungsförderung bei Erwachsenen, die bezüglich Wirksamkeit und breiter Umsetzung ein beträchtliches Potenzial haben. Beispiele sind Interventionen in der Gemeinde, der Arztpraxis oder am Arbeitsplatz. Das Verletzungsrisiko durch solche Bewegungsförderungsansätze sollte erforscht werden. Ausserdem sollte mit methodisch guten Studien die Frage untersucht werden, ob die Verbesserung der allgemeinen Fitness, insbesondere der koordinativen Fähigkeiten, bei jüngeren Kindern die Anzahl Verletzungen reduziert.

Einige wichtige Forschungsfragen zu den Zusammenhängen zwischen Bewegungsverhalten und Verletzungsrisiko sind immer noch unbeantwortet. Trotzdem gibt es bereits fundierte Hinweise darauf, dass Bewegungsförderung und Unfallprävention

eher Verbündete denn Gegenspieler sind. Die optimalen Auswirkungen auf die Gesundheit und die optimale Nutzung der Ressourcen wird man erreichen, wenn die oben formulierten Empfehlungen in der Umsetzung berücksichtigt werden. Die Empfehlungen für die Forschung werden es erlauben, die Evidenz zu stärken und zu weiteren Fortschritten in der Praxis der Bewegungsförderung und Unfallprävention beizutragen.

3. Promotion de l'activité physique et prévention des accidents

3.1 Introduction

Les effets positifs d'une activité physique régulière sur la santé et le bien-être sont largement reconnus. Les connaissances en la matière ont été mises à jour en 2008 par le comité américain «Physical Activity Guidelines Advisory Committee». Néanmoins, le niveau d'activité physique en Suisse, même s'il semble en hausse, reste faible: selon les enquêtes suisses sur la santé, la part des adultes ayant une activité physique suffisante a passé de 36% en 2002 à 41% en 2007.

Les accidents entraînant des blessures voire la mort constituent un grave problème de santé publique. En dépit des importants efforts de prévention consentis depuis des décennies, la Suisse fait chaque année état de près d'un million d'accidents non professionnels occasionnant des blessures ou la mort. 100 000 personnes sont blessées dans des accidents de la route, 300 000 en pratiquant des activités sportives et 600 000 dans l'habitat ou durant des loisirs autres que le sport. Quelque 2000 personnes perdent la vie chaque année dans des accidents non professionnels.

Un lien de causalité direct est parfois établi, en particulier dans l'opinion publique, entre la hausse du niveau d'activité physique et l'augmentation des accidents de sport. Inversement, certains pensent qu'une activité physique plus régulière induit une baisse des accidents. La diversité des points de vue illustre la complexité de la relation entre le comportement de la population en matière d'activité physique et l'accidentologie. Une large approche de la question ne peut pas seulement considérer la

relation entre l'activité physique et les accidents de sport, mais doit tenir compte des accidents et blessures de toute sorte. Il est p. ex. possible que les personnes physiquement actives aient moins de blessures dans d'autres domaines car elles sont plus en forme. Le présent rapport se propose de donner une vue d'ensemble de la littérature scientifique existant sur cette relation pour différents groupes d'âge de la population. Les principales questions soulevées sont, d'une part, de savoir si une population physiquement active a, globalement, plus ou moins de blessures qu'une population inactive et, d'autre part, dans quelles conditions la promotion de l'activité physique en soi peut prévenir les accidents.

3.2 Méthode

Le rapport du comité américain a servi de point de départ à cette étude, en particulier les parties traitant de la santé fonctionnelle (chutes et blessures liées à celles-ci chez les personnes âgées) et des effets pervers du sport (blessures musculo-squelettiques). Dans un deuxième temps, les bases de données de littérature scientifique ont été épluchées en vue de trouver des revues de la littérature et articles publiés entre 2007 et 2009 ainsi que des publications européennes antérieures sur les sujets discutés dans le rapport du comité. Dans un troisième temps, ces listes ont été complétées par des rapports et d'autres formes de littérature grise de Suisse. Enfin, des institutions et experts étrangers choisis ont été invités à commenter une première version du rapport.

3.3 Résultats

Les études ne distinguent généralement pas les blessures traumatiques de celles résultant d'une surcharge. Les études qui ne font pas la distinction ont dès lors été intégrées dans la vue d'ensemble de la littérature alors que celles qui examinent explicitement les blessures de surcharge ont été écartées. La question générale de la relation entre l'activité physique et le risque global de blessures n'est guère traitée en soi. Mais nombre d'études se sont penchées sur des questions plus spécifiques, qui diffèrent sensiblement au long de la vie.

3.3.1 Population d'âge actif

On a pu identifier quelques études d'observation procédant à une analyse transversale des données, qui traitent de la relation entre une activité physique habituelle et les blessures qui y sont liées ainsi que les blessures en général. De plus, un petit nombre d'enquêtes sur la population suisse a permis d'approfondir les connaissances. Il a en revanche été impossible de trouver des études longitudinales prospectives portant sur des adultes entre 45 et 65 ans.

Principaux résultats:

- On dispose de bonnes preuves sur la forte variation du risque de blessures selon le sport ou l'activité physique.
- On dispose de preuves constantes sur la relation, dans la population en général, entre un plus haut niveau d'activité physique, en particulier en termes d'intensité, et un plus grand nombre de blessures liées à celle-ci. Il est parfois suggéré que les blessures en lien avec l'activité physique sont plus graves chez les personnes qui ne sont pas actives physiquement

de façon régulière. On dispose d'indications suggérant qu'un plus haut niveau d'activité physique n'implique pas nécessairement un risque global de blessures plus élevé.

- Des études d'intervention apportent quelques preuves de l'influence de la fréquence, de la durée, de l'intensité et du type d'activité physique sur le risque de blessures liées au sport ainsi que du faible taux de blessures (sans qu'il ait été mesuré avec précision) lors de la pratique d'une activité physique d'intensité modérée.

3.3.2 Personnes âgées

Les chutes et les fractures ostéoporotiques sont les principaux effets sur la santé étudiés chez les personnes âgées. Le rapport du comité américain «Physical Activity Guidelines Advisory Committee» comprend huit revues systématiques de la littérature ou méta-analyses d'essais d'intervention traitant des effets des programmes d'activité physique sur le risque de chute. Les preuves concernant le risque de fracture ostéoporotique, principalement de la hanche (col du fémur), se basent sur des études prospectives de cohorte ou de cas-témoins. Un vaste essai contrôlé randomisé fait toujours défaut.

Principaux résultats:

- Pour les personnes âgées présentant un risque accru de chute, on dispose de bonnes preuves quant au fait que la participation à des programmes d'activité physique peut réduire le risque de chute quelle que soit sa cause. Les preuves sont le plus évidentes pour les activités physiques qui incluent un entraînement de la force, de l'équilibre et de l'endurance, en particulier la marche. De plus, les preuves sur les bénéfices du Tai Chi sont de plus en plus nombreuses.

- Les preuves sont moyennes à bonnes que, chez les personnes âgées, un plus haut niveau d'activité physique est lié à un moindre risque de fractures ostéoporotiques, en particulier de la hanche. On dispose de quelques preuves sur le fait qu'une baisse de l'activité physique durant les loisirs se traduit relativement rapidement par un risque accru de fracture de la hanche. Les preuves en faveur du mécanisme inverse, c.-à-d. une augmentation volontaire de l'activité physique durant les loisirs qui conduit à une baisse du risque de fracture de la hanche, sont légèrement moins bonnes.
- Les preuves quant au fait que les programmes de prévention des chutes pour l'ensemble de la population peuvent eux aussi réduire le risque de blessures liées aux chutes quelle que soit leur cause sont modérées.
- se blessent davantage que les filles, mais si l'on considère l'exposition à l'activité physique, cette différence entre les sexes est moins claire.
- On dispose de preuves constantes sur l'étroite relation entre la pratique de sports ou d'activités intenses et un risque accru de blessures d'origine sportive. Il existe par ailleurs quelques preuves en faveur d'une relation dose-effet.
- On dispose de quelques éléments probants quant au fait que la pratique de sports ou d'activités intenses se traduit par un risque accru de fractures et de blessures quelle que soit leur cause.
- Quelques études fournissent des preuves limitées suggérant qu'il n'y a *pas* de lien entre activités non sportives et risque global de blessures, et que les activités d'intensité modérée pourraient prévenir les fractures.

3.3.3 Enfants et adolescents

Hormis quelques études longitudinales, la littérature est dominée, pour ces groupes d'âge, par des études transversales visant à identifier les facteurs de risque des blessures. L'exposition est généralement mesurée par la pratique de sports ou d'activités intenses. Etant donné la prédominance de cette approche pathogénétique de la relation entre activité physique et risque de blessures, d'autres comportements en matière d'activité physique (p. ex. activité d'intensité modérée) qui ne sont pas nécessairement associés au risque de blessures ou qui pourraient même prévenir celles-ci sont rarement étudiés ou leurs résultats ne sont pas publiés.

Principaux résultats:

- Le risque de blessures augmente de la pré-adolescence jusqu'à 15 ans environ. Les garçons

3.3.4 Populations spécifiques

Chez les **athlètes**, les blessures sont courantes; des blessures antérieures sont un fort indicateur de l'incidence des blessures. C'est pourquoi il est très important d'intervenir afin de réduire le risque de blessures chez les athlètes. Par ailleurs, les études menées sur des **recrues de l'armée** peuvent servir de modèles pour illustrer différents aspects de la relation entre l'activité physique et le risque de blessures, car tant le niveau d'activité physique que le risque global de blessures sont élevés. Comme montré précédemment pour la prévention des chutes chez les personnes âgées, il existe des preuves quant au fait que des programmes d'entraînement spécifiques peuvent réduire le risque de blessures chez les personnes qui s'approchent de ou tutoient la limite de leurs capacités. Dans tous ces cas, des interventions ciblées semblent le plus efficaces.

Principaux résultats:

- Des entraînements spécifiques se sont révélés efficaces pour réduire les blessures sportives chez les athlètes. La force des preuves dépend de la discipline sportive, du groupe cible, des éléments d'entraînement et du type de blessures considéré.
- La formation à l'armée se caractérise par un haut niveau d'activité physique, un fort risque de blessures et des différences parfois considérables dans la pratique antérieure d'une activité physique et le niveau de forme entre les recrues à leur entrée. Il existe des preuves constantes quant au fait que les blessures sont plus fréquentes chez les recrues peu entraînées. Un certain nombre d'études ont montré que l'incidence des blessures peut être réduite grâce à des programmes de préparation physique spécifiques.
- On ne peut pas encore dire clairement dans quelle mesure ces résultats peuvent être généralisés à l'ensemble de la population.

3.3.5 Directives nationales et recommandations dans d'autres pays

Des experts du domaine de la promotion de l'activité physique et de la prévention des accidents travaillant à l'institut EMGO de l'université libre d'Amsterdam (Pays-Bas) et aux Centres for Disease Control CDC d'Atlanta (Etats-Unis) ont fourni des informations sur la situation dans leur pays et ont commenté le rapport. Aux Etats-Unis, des recommandations spécifiques en vue de la pratique sûre des activités physiques ont été intégrées dans les directives nationales en matière d'activité physique édictées en 2008. Les recommandations formulées dans le présent rapport vont dans le sens des directives américaines. Les Pays-Bas, quant à eux,

n'ont pas de politique spécifique en la matière. Les experts néerlandais sont néanmoins d'accord avec les recommandations de ce rapport.

3.4 Discussion et conclusions

3.4.1 Synthèse

Les revues de la littérature et études considérées pour le présent rapport fournissent des éléments de connaissances sur la relation complexe entre la promotion de l'activité physique et la prévention des accidents pour la population en général. La fig. 1, p. 28 est une synthèse, tout au long de la vie – de l'enfance jusqu'à un âge avancé –, des liens entre activité physique et santé, d'une part, et de la relation possible entre activité physique et risque d'accident, d'autre part. C'est un fait que la pratique d'une activité physique est bénéfique pour la santé à tout âge. La promotion de l'activité physique chez les personnes âgées permet aussi de réduire le risque d'accident. Chez les adultes d'âge actif, l'activité physique semble être associée à un plus grand nombre de blessures liées à celle-ci, mais pas nécessairement de blessures en général. Les enfants et les adolescents qui font beaucoup de sport ou pratiquent des activités physiques intenses ont un risque global de blessures plus élevé. En résumé, on a un certain nombre de connaissances sur la direction dans laquelle va la relation entre activité physique et risque d'accident pour différents groupes d'âge. En revanche, des travaux de recherche sont encore nécessaires pour déterminer avec assurance l'importance de cette relation et les âges où elle change en termes d'ampleur et de direction.

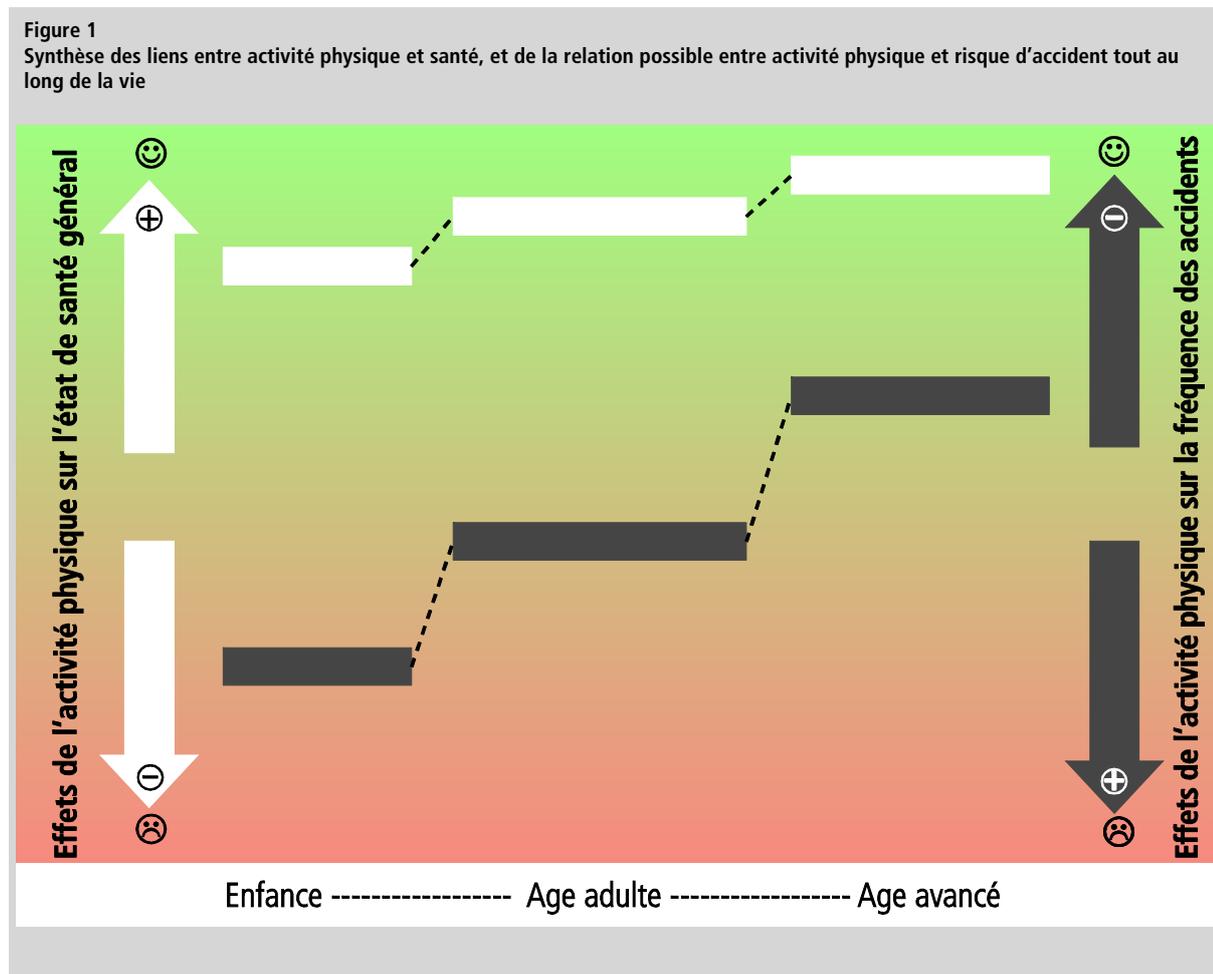
D'une manière générale, ce domaine de recherche semble encore en être à ses balbutiements. Hormis pour les personnes âgées, il n'existe que très peu d'articles sur la relation entre la promotion de l'activité physique et la prévention des accidents d'un point de vue salutogénétique. La plupart des études visent à identifier les facteurs de risque des blessures. Par conséquent, les facteurs liés au comportement en matière d'activité physique qui pourrait prévenir les blessures sont rarement étudiés, et si aucune relation n'est identifiée – p. ex. si le comportement n'est pas un facteur de risque –, il est probable que les résultats ne soient pas publiés. En l'absence d'indicateurs et de méthodes standardisés pour mesurer l'exposition et les effets sur la santé, il est difficile de comparer les études. Le nombre d'études prospectives est limité et les

études transversales qui déterminent l'occurrence des accidents de manière rétrospective ont des limites méthodologiques. Avec ces dernières, il ne peut pas être exclu qu'une blessure ait eu une influence sur le comportement en matière d'activité physique et que le lien de causalité entre activité physique et risque de blessures soit dès lors inversé.

3.4.2 Recommandations pour la mise en œuvre

En dépit de ses limites, l'état actuel des connaissances permet de formuler les recommandations suivantes pour la mise en œuvre:

- **Enfants et jeunes: lier promotion de l'activité physique et prévention des accidents.**



La promotion de l'activité physique et du sport chez les enfants est un important travail de santé publique. Pour éviter une hausse des accidents, il est important, à cet âge, d'accompagner la promotion de l'activité physique par l'ensemble des mesures de prévention des accidents.

- **Adultes: encourager les bons choix dans la promotion de l'activité physique.** Il s'agit d'encourager les adultes à maintenir ou à améliorer leur comportement en matière d'activité physique et de sport, en les aidant à choisir des activités adaptées à leur âge, leur forme physique et leur expérience. Les sollicitations devraient être augmentées progressivement.
- **Personnes âgées: promotion de l'activité physique est synonyme de prévention des accidents.** Le maintien ou l'augmentation de l'activité physique chez les personnes âgées contribue à leur autonomie, et permet de réduire chutes et fractures. Des programmes d'entraînement multidimensionnels semblent le plus efficaces. Il y a lieu de tenir compte des mesures générales de prévention des accidents.

3.4.3 Recommandations pour la recherche

Le rapport du comité américain «Physical Activity Guidelines Advisory Committee» a identifié un certain nombre de besoins en matière de recherche en ce qui concerne les effets indésirables de l'activité physique. Premièrement, il faudrait examiner si les personnes actives et celles inactives physiquement ont le même risque global d'accident. Ensuite, la recherche doit se concentrer sur la dose d'activité physique adaptée aux débutants et son augmentation progressive en vue d'éviter les blessures qui y sont liées. En matière de prévention des chutes chez les personnes âgées, il n'est pas encore

clair quels programmes sont le mieux adaptés aux différents groupes et s'il existe un seuil d'efficacité ou une relation dose-effet pour l'activité physique. De plus, un essai contrôlé randomisé suffisamment vaste visant à déterminer les effets de l'activité physique sur le risque de fractures fait encore défaut. Globalement, il paraît très important de quantifier encore davantage la relation entre l'activité physique et le risque de blessures ainsi que les effets des interventions, afin d'examiner les spécificités et différences entre les divers groupes d'âge, et de vérifier que les expériences acquises pour des groupes particuliers (p. ex. athlètes ou recrues) peuvent être généralisées à l'ensemble de la population. Les recommandations spécifiques suivantes peuvent en être déduites:

- **Exploiter les données existantes et améliorer la méthodologie.** On dispose d'indications sur le fait qu'un certain nombre d'enquêtes et d'études ont recueilli des informations sur l'exposition et les effets sur la santé, mais les relations intéressantes pour le présent rapport n'ont pas été examinées ou publiées. Des progrès dans les méthodes d'évaluation du comportement en matière d'activité physique et du risque de blessures permettront d'acquérir de nouvelles connaissances.
- **Réaliser des études de population à caractère prospectif** et dont la méthodologie est appropriée: elles sont nécessaires tant pour les enfants que pour les adultes.
- **Etudier les effets de la promotion de l'activité physique sur le risque de blessures.** Certaines mesures de promotion de l'activité physique ciblées sur les adultes ont un grand potentiel en termes d'efficacité et de mise en œuvre à une large échelle (p. ex. interventions dans les communes, les cabinets médicaux ou au travail). Il s'agit d'étudier leurs effets sur le

risque de blessures. De plus, des études se caractérisant par une bonne méthodologie devraient se pencher sur la question de savoir si des mesures d'amélioration de la forme physique générale chez les jeunes enfants, en particulier leur coordination et leurs facultés motrices, permettent de réduire le nombre de blessures.

Un certain nombre d'importantes questions de recherche sur la relation entre l'activité physique et le risque de blessures restent sans réponse. On dispose néanmoins déjà de fortes indications sur le fait que la promotion de l'activité physique et la prévention des accidents sont des alliées plutôt que des adversaires. L'application des recommandations pratiques susmentionnées permettra d'atteindre un effet optimal sur la santé publique et l'utilisation optimale des ressources. Les recommandations en matière de recherche permettront de renforcer les preuves et de continuer à progresser en pratique dans la promotion de l'activité physique et la prévention des accidents.

4. Promozione dell'attività fisica e prevenzione degli infortuni

4.1 Introduzione

Gli effetti positivi di un'attività fisica regolare sulla salute e il benessere sono ampiamente riconosciuti, l'evidenza è stata aggiornata nel 2008 dall'US Physical Activity Guidelines Advisory Committee. Nonostante, in Svizzera i livelli di attività fisica sono ancora bassi, ma sembrano essere in aumento: secondo le indagini sulla salute in Svizzera, la percentuale degli adulti sufficientemente attivi è aumentata dal 36% nel 2002 al 41% nel 2007.

Gli incidenti che comportano lesioni o persino la morte sono un enorme problema di Sanità Pubblica. Nonostante i ragguardevoli sforzi antinfortunistici intrapresi negli ultimi decenni, in Svizzera si conta ogni anno quasi un milione di infortuni non professionali che comportano una lesione o la morte. 100 000 persone si infortunano nella circolazione stradale, 300 000 nello sport e 600 000 in casa o durante un'attività del tempo libero diversa dallo sport. Circa 2000 persone muoiono ogni anno in seguito a un infortunio non professionale.

A volte, e in particolare nell'opinione pubblica, si stabilisce direttamente un nesso causale tra l'aumento dell'attività fisica e l'incremento degli infortuni nello sport. Dall'altro lato, a volte si dice che una maggiore attività fisica comporta una riduzione degli infortuni. Punti di vista talmente opposti illustrano la relazione complessa tra attività fisica e il peso degli infortuni sulla popolazione. Una prospettiva ampia su questo problema non può considerare solo i nessi tra attività fisica e infortuni sportivi, ma deve tener conto di infortuni

di qualsiasi causa. È per esempio possibile che una persona attiva sia colpita da meno infortuni in altri contesti grazie alla migliore forma fisica. Questo studio persegue l'obiettivo di offrire una panoramica sulla letteratura scientifica relativa a questi nessi per diverse fasce d'età della popolazione. Le questioni chiave sono: 1) complessivamente una popolazione attiva subisce più o meno infortuni rispetto a una popolazione inattiva e 2) sotto quali circostanze la promozione dell'attività fisica come tale può prevenire gli infortuni.

4.2 Metodi

Il rapporto dell'US Physical Activity Guidelines Advisory Committee è servito come punto di partenza, in particolare le parti relative alla salute funzionale (cadute e infortuni correlati a una caduta tra gli anziani) e sugli eventi avversi (infortuni muscoloscheletrici). In un secondo passo, nelle banche dati della letteratura scientifica si è cercato gli studi pubblicati tra il 2007 e il 2009 e le pubblicazioni europee precedenti sugli argomenti discussi nel rapporto dell'Advisory Committee. In un terzo passo, si è completato la lista delle opere di riferimento con rapporti e altre forme di letteratura grigia proveniente dalla Svizzera. In un quarto e ultimo passo, si è chiesto a selezionate istituzioni e a esperti di altri Paesi di commentare una prima versione del rapporto.

4.3 Risultati

Generalmente la letteratura non fa differenza tra infortuni traumatici e infortuni risultanti da sovraccarico. Per questo motivo, gli studi che non hanno fatto nessuna differenza sono stati inclusi in questa panoramica della letteratura, mentre sono stati esclusi gli studi che hanno analizzato gli infortuni

da sovraccarico. La domanda principale che indaga sui nessi tra comportamento durante l'attività fisica e il rischio d'infortunio totale non viene quasi mai rivolta come tale. È, invece, stato possibile scoprire alcuni studi che hanno analizzato questioni di ricerca più specifiche che si differenziano notevolmente nell'arco della vita.

4.3.1 Popolazione in età lavorativa

Sono stati trovati alcuni studi osservativi con analisi trasversale dei dati dedicati sia ai legami tra attività fisica abituale e infortuni relativi all'attività sia a tutti i tipi di infortuni. Un esiguo numero di indagini tra la popolazione svizzera ha fornito ulteriori delucidazioni. Non sono stati trovati studi sugli adulti tra 45 e 65 anni con disegno prospettico longitudinale.

Evidenze scientifiche in breve:

- c'è una buona evidenza per ampie differenze di rischi d'infortunio in specifici sport o attività;
- ci sono alcune evidenze consistenti che livelli più elevati di attività fisica, in particolare in merito all'intensità, sono legati a un numero più alto di infortuni correlati all'attività nella popolazione. Ci sono alcuni indizi che gli infortuni correlati all'attività fisica potrebbero essere più gravi rispetto a quelli che non sono legati a un'attività fisica regolare. Da alcuni studi emerge che livelli più elevati di attività fisica non sono necessariamente correlati a un maggiore rischio d'infortunio generale;
- ci sono alcune evidenze ottenute da studi di intervento secondo cui l'insieme di frequenza, durata, intensità e tipo di attività contribuisce al rischio di subire un infortunio correlato a un'attività fisica e che un'attività fisica di intensità moderata sembra avere delle percen-

tuali di infortuni basse (ma non rilevato in modo preciso).

4.3.2 Anziani

Tra gli anziani, le cadute e le fratture osteoporotiche sono i principali outcome d'interesse. L'US Physical Activity Guidelines Advisory Committee ha incluso otto review sistematiche o meta-analisi di studi di intervento per analizzare gli effetti dei programmi di attività fisica sul rischio di caduta. L'evidenza rispetto al rischio di fratture osteoporotiche, in particolare dell'anca, è basata su studi di coorte prospettici e caso-controllo. Manca tuttora un'ampio studio controllato randomizzato.

Evidenze scientifiche in breve:

- per gli anziani con un rischio di caduta più alto c'è una chiara evidenza che la partecipazione a programmi di attività fisica può ridurre il rischio di caduta per qualsiasi causa. L'evidenza più forte emerge per i programmi di attività fisica che rafforzano i muscoli, allenano l'equilibrio e contengono attività aerobiche, specialmente camminare. Inoltre, c'è una maggiore evidenza che gli esercizi di Tai Chi hanno un effetto positivo;
- c'è evidenza media fino a buona che tra gli anziani un livello più elevato di attività fisica è associato a un minore rischio di fratture osteoporotiche, in particolare dell'anca. Esistono delle evidenze che una minore attività fisica nel tempo libero comporta un aumento delle fratture dell'anca dopo un lasso di tempo relativamente breve. L'evidenza che una decisione autonoma di aumentare l'attività fisica nel tempo libero è associata a un calo delle fratture dell'anca è leggermente meno marcata;
- c'è evidenza moderata che suggerisce che

anche la prevenzione delle cadute per l'insieme della popolazione può ridurre il rischio di infortuni correlati a una caduta dovuta a qualsiasi causa.

4.3.3 Bambini e adolescenti

A prescindere da pochi studi longitudinali, gli studi trasversali per l'identificazione dei fattori di rischio per gli infortuni dominano la letteratura per questa fascia d'età. L'esposizione è normalmente una misura di partecipazione sportiva o attività vigorosa. Data questa prospettiva patogenetica predominante del rapporto tra attività fisica e rischio d'infortunio, altri comportamenti relativi all'attività fisica (p. es. attività di intensità moderata) che non potrebbero essere associate a un rischio d'infortunio o potrebbero persino proteggere da infortuni sono raramente studiati oppure i relativi risultati non sono pubblicati.

Evidenze scientifiche in breve:

- a partire dalla preadolescenza, il rischio d'infortunio aumenta fino all'età di 15 anni circa. I ragazzi hanno più infortuni che le ragazze; comunque, se si considera l'esposizione rispetto all'attività fisica, questa differenza tra i sessi diventa meno palese;
- c'è evidenza consistente che la partecipazione ad attività sportive o attività vigorose è fortemente associata a un maggiore rischio di infortuni sportivi e si riscontra evidenza per la relazione dose-risposta in questo contesto;
- c'è evidenza che la partecipazione ad attività sportive o vigorose sembra essere associata a un maggiore rischio di fratture e infortuni di qualsiasi causa;
- solo da pochi studi emerge un'evidenza limitata che le attività non sportive non sono associate a

infortuni di qualsiasi causa e che le attività non vigorose potrebbero proteggere da fratture.

4.3.4 Popolazioni specifiche

Tra gli **atleti** gli infortuni sono frequenti e gli infortuni precedenti un notevole fattore di rischio per nuove lesioni. Si impongono, pertanto, degli interventi per ridurre il rischio d'infortunio tra gli atleti. Studi effettuati su **reclute dell'esercito** possono servire come modello per illustrare gli aspetti differenti del rapporto tra attività fisica e il rischio d'infortunio, perché nell'esercito è alto sia il livello di attività fisica sia il rischio d'infortunio. Come già mostrato per la prevenzione delle cadute tra gli anziani, si riscontra evidenza che un allenamento specifico può ridurre il rischio di infortuni tra le persone che devono raggiungere prestazioni vicine ai limiti o persino ai limiti delle loro capacità. In tutti questi casi, gli interventi mirati sembrano rivelarsi i più efficaci.

Evidenze scientifiche in breve:

- per la riduzione degli infortuni sportivi tra gli atleti si sono dimostrati efficaci gli interventi d'allenamento specifici. La misura dell'evidenza per l'efficacia dipende dallo sport, dal target, dagli elementi d'intervento e dal tipo di infortunio analizzato;
- l'addestramento militare è caratterizzato da un elevato livello di attività fisiche, da un grande rischio d'infortunio e da a volte considerevoli differenze nelle attività fisiche e nella resistenza fisica che precedono il servizio militare. C'è un'evidenza consistente che gli infortuni sono più frequenti tra le reclute con una resistenza fisica bassa. Da diversi studi è emerso che l'incidenza di infortuni può essere ridotta con uno specifico programma di allenamento;

- non è ancora chiaro fino a quale punto questi risultati possono essere generalizzati per altri gruppi della popolazione.

Paesi Bassi non dispongono di direttive specifiche, comunque, gli esperti condividono i consigli contenuti nel rapporto.

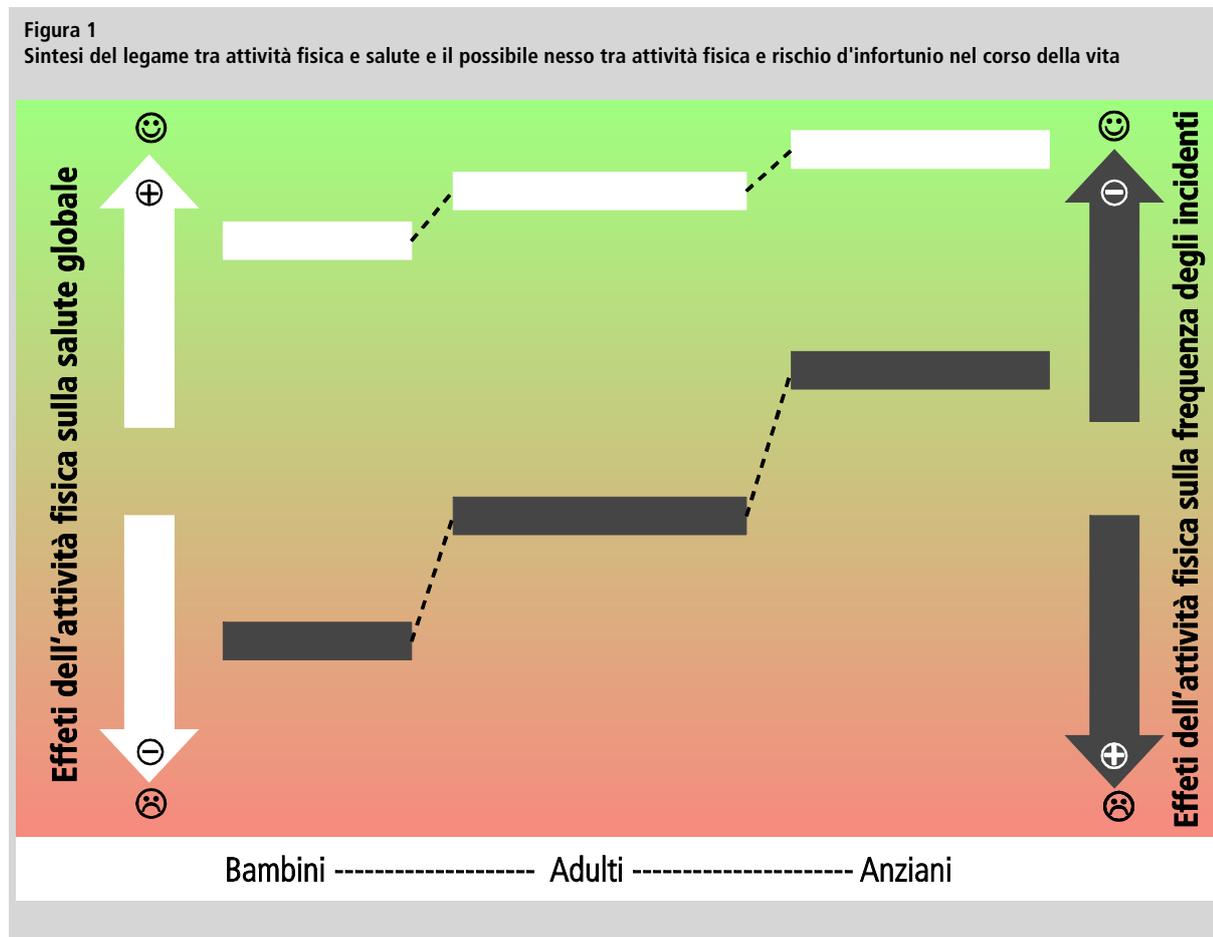
4.3.5 Direttive nazionali e consigli in altri Paesi

Esperti nell'ambito della promozione dell'attività fisica e della prevenzione degli infortuni dell'Istituto EMGO dell'Università libera di Amsterdam (Paesi Bassi) e del Centres for Disease Control CDC ad Atlanta (USA) hanno fornito informazioni sulla situazione nei loro Paesi e hanno commentato il rapporto. Negli USA, consigli specifici per un'attività fisica sicura sono stati inseriti nelle direttive nazionali relative all'attività fisica pubblicate nel 2008. I consigli formulati in questo rapporto sono in linea con le direttive statunitensi. I

4.4 Discussione e conclusioni

4.4.1 Sintesi

Le analisi e gli studi identificati per questo rapporto permettono di avere un'idea sulla relazione complessa tra promozione dell'attività fisica e prevenzione degli infortuni per la popolazione. La figura 1 illustra in sintesi l'evidenza relativa al legame tra attività fisica e la salute generale nel corso della vita e sulla possibile relazione tra attività fisica e il rischio d'infortunio dall'infanzia fino all'anzianità. C'è evidenza elevata che l'attività fisica è positiva per la salute di tutte le fasce d'età. Con la



promozione dell'attività fisica tra gli anziani si riduce anche il rischio d'infortunio. Tra gli adulti in età lavorativa, l'attività fisica sembra essere legata a un maggior numero di infortuni correlati a un'attività fisica ma non necessariamente a un maggior numero di infortuni in generale. I bambini e gli adolescenti che praticano molto sport o attività vigorose sono maggiormente coinvolti in infortuni di qualsiasi tipo di causa. In totale, c'è evidenza su come il legame tra attività fisica e rischio d'infortunio si ripercuote sulle diverse fasce d'età. Tuttavia bisogna ancora studiare quando cambiano i nessi e le fasce d'età.

Complessivamente, questo tipo di ricerca sembra ancora trovarsi agli albori. Tranne degli studi con anziani, esistono solo pochissime ricerche che analizzano i legami tra attività fisica e prevenzione degli infortuni da un punto di vista salutogenico. La maggior parte degli studi mira all'identificazione dei fattori di rischio per gli infortuni. Di conseguenza, le attività fisiche correlate a fattori comportamentali che potrebbero prevenire gli infortuni sono raramente oggetto di ricerca e se non si trova alcun legame, in particolare se il comportamento non è un rischio per l'infortunio, spesso questi risultati non vengono pubblicati. Gli indicatori e i metodi per misurare l'esposizione e gli outcome non sono standardizzati, rendendo così difficile il paragone dei singoli studi. Il numero di studi prospettici è limitato e gli studi trasversali che determinano l'occorrenza degli incidenti in modo retrospettivo dispongono di limiti metodologici. Con una valutazione retrospettiva di percentuali d'infortunio non si può escludere che un infortunio abbia influenzato le abitudini relative all'attività fisica e che per questo motivo le cause dei legami tra attività fisica e infortunio siano invertite.

4.4.2 Consigli per l'implementazione

Nonostante i suoi limiti, l'attuale stato dell'evidenza permette di dare i seguenti consigli specifici per l'implementazione e la pratica:

- **bambini e giovani: collegare la promozione dell'attività fisica e la prevenzione degli infortuni.** La promozione dell'attività fisica e dello sport tra i bambini è un compito importante della Sanità Pubblica. Per evitare un incremento degli infortuni, in questa fascia d'età è importante fiancheggiare la promozione di attività fisiche con tutte le misure della prevenzione degli infortuni;
- **adulti: sostenere le scelte giuste nella promozione dell'attività fisica.** Gli adulti vanno incoraggiati a mantenere e aumentare le loro attività sportive e fisiche. Vanno sostenuti nella scelta di attività appropriate alla loro età e il loro livello individuale di resistenza fisica ed esperienza e i programmi d'allenamento vanno introdotti gradualmente;
- **anziani: la promozione dell'attività fisica equivale alla prevenzione degli infortuni.** Mantenere e aumentare l'attività fisica tra gli anziani aiuta queste persone a restare indipendenti e a ridurre le cadute e fratture. I programmi multidimensionali sembrano essere i più efficienti e le misure generali per prevenire gli infortuni vanno adottate.

4.4.3 Consigli per la ricerca

Il rapporto del Physical Activity Advisory Committee ha identificato un numero di lacune di ricerca relative all'attività fisica e agli eventi avversi: 1) va posta la domanda se per le persone attive e inattive si presenta il medesimo rischio; 2) sono necessarie delle ricerche su quali siano le dosi iniziali e le

quantità di aumento appropriate per prevenire gli infortuni correlati a un'attività fisica tra coloro che iniziano a essere fisicamente più attivi; 3) nella prevenzione delle cadute tra gli anziani non è ancora chiaro quali programmi siano i più adatti per quale gruppo e se in merito all'efficacia esista una soglia minima o un rapporto dose-effetto relativo all'attività fisica; 4) manca tuttora uno studio randomizzato controllato sufficientemente ampio per determinare l'effetto dell'attività fisica sul rischio di frattura; 5) infine sembra molto importante poter quantificare maggiormente il rapporto tra attività fisica e rischio d'infortunio come anche gli effetti degli interventi per risalire alle specificità e alle differenze tra le fasce d'età e per verificare la generalizzabilità delle esperienze di gruppi specifici come atleti o reclute. Si possono formulare i seguenti consigli specifici:

- **usare tavole di dati esistenti (dataset) e migliorare i metodi.** Ci sono indicazioni che una quantità di survey e studi hanno fornito informazioni sull'esposizione e sugli outcome, ma che non sono stati analizzati o pubblicati i nessi d'interesse per questo rapporto. Ulteriori progressi nei metodi di valutazione sia per l'attività fisica sia per gli infortuni forniranno nuovi risultati;
- **condurre studi basati sulla popolazione con design prospettivo.** Tra i bambini e gli adulti sono necessari degli studi di popolazione con design prospettivo e metodologia adeguata;
- **valutare gli effetti della promozione dell'attività fisica sul rischio d'infortunio.** Ci sono promozioni dell'attività fisica per gli adulti che dispongono di un elevato potenziale sia di efficacia sia di realizzazione su vasta scala: per esempio gli interventi nel comune, nello studio medico o sul lavoro. I loro effetti sul rischio d'infortunio dovrebbero essere analizzati.

Inoltre, la questione se gli interventi per promuovere la condizione fisica generale e in particolare la coordinazione o le capacità motorie tra i bambini piccoli riduce il numero di infortuni andrebbe analizzata con degli studi metodicamente buoni.

Sono ancora senza risposta alcuni quesiti di ricerca importanti concernenti la relazione tra attività fisica e rischio d'infortunio. Tuttavia, ci sono forti indizi che la promozione dell'attività fisica e la prevenzione degli infortuni sono alleati e non antagonisti. L'effetto ottimale sulla salute pubblica e l'uso ottimale delle risorse saranno raggiunti con l'adozione dei consigli pratici menzionati precedentemente. I consigli per la ricerca permetteranno di rafforzare l'evidenza e di contribuire a ulteriori progressi nella prassi della promozione dell'attività fisica e della prevenzione degli infortuni.

II. Introduction

1. Background

The importance of physical activity for public health is well known. Nevertheless, many people are not active enough and the burden of disease and economic costs attributable to physical inactivity are worrisome. It is well recognised that the promotion of physical activity is a key element in strategies aimed at improving population health.

Injuries can occur not only in relation to sports or leisure time physical activity, but also in the traffic, in the household, during work or as a result of violence. The burden of disease and economic costs caused by injuries from different causes are substantial. This makes also injury prevention an important public health topic.

Sometimes, and in particular in the perception of the public, a direct causal link is established between rising levels of physical activity and increases in sports injuries. On the other hand, it is sometimes stated that more physical activity will lead to a reduction of injuries. Such diverse views illustrate that the relationship between physical activity behaviour and the burden of injury in the population is complex. The purpose of this report is to give an overview of the scientific literature regarding this relationship for different age groups of the general population. After an introduction on the principles of physical activity promotion and of injury prevention this report will give an overview of the evidence focussing on the general question: Are physical activity promotion and injury prevention adversaries or allies?

2. Physical activity promotion

2.1 Physical activity and health

The positive effects of regular physical activity on health and well-being are well known and documented in the literature. In 1996 the Surgeon General's Report on physical activity and health provided for the first time the compiled evidence for the positive effects of physical activity on many widespread health outcomes [1]. The report was updated in 2008 by the US Physical Activity Guidelines Advisory Committee [2]. The current evidence for the health benefits of physical activity was summarised for different age groups:

- Middle age and older adults: There is strong evidence that more active persons have lower rates of all-cause mortality, coronary heart disease, high blood pressure, stroke, type 2 diabetes, metabolic syndrome, colon cancer, breast cancer, and depression. Furthermore, physically active adults and older adults have higher levels of cardio-respiratory and muscular fitness, a healthier body mass and composition, and a biomarker profile that is more favourable for preventing cardiovascular disease and type 2 diabetes and for enhancing bone health. Modest evidence indicates that physically active adults and older adults have better quality sleep and health-related quality of life. Additionally, there is strong evidence that among older adults more active individuals have higher levels of functional health, a lower risk of falling, and better cognitive function (Table 1, p. 38).

– Children and Adolescents: There is strong evidence that physical fitness and health status are substantially improved by frequent physical activity. In comparison to inactive individuals, physically active children and adolescents have higher levels of cardio-respiratory endurance and muscular strength, reduced body fatness, more favourable cardiovascular and metabolic disease risk profiles, enhanced bone health, and reduced symptoms of anxiety and depression (Table 1).

of these recommendations are considered to be sufficiently active. Furthermore it is recommended to perform strength and flexibility training two times a week [4].

In 2007 and 2008 respectively, the US recommendations for adults from 1995 [3] have been updated by the American College of Sports medicine (ACSM) and the American Heart Association (AHA) [5] as well as by the US Department of Health and Human Services (USDHHS) [6]. Today, at least 150 minutes of moderate intensity activity or 75 minutes of vigorous activities per week or an equivalent dose of a combination of moderate and vigorous intensity activities are recommended. Aerobic activity should be performed in episodes of at least 10 minutes, and preferably, it should be spread throughout the week. [5,6]. ACSM and AHA still recommend being active on at least five days a week while the USDHHS has phrased the issue of regularity less stringently focussing on the weekly amount of «two hours and 30 minutes a week of moderate-intensity, or one hour and 15 minutes a

2.2 Physical activity recommendations for adults

A few years after the first U.S. recommendations [3] the Swiss physical activity recommendations for adults were issued based on the best available evidence in 1999. They remain unchanged until today: Adults should accumulate at least half an hour of moderate intensity activities on most days of the week. Alternatively, they can be active vigorously during at least three weekly sessions of 20 to 60 minutes. Individuals who meet either one

Health benefits of physical activity			
in adults		in children	
↑ Life expectancy	↓ Coronary heart disease	↑ Physical fitness	↓ Body fatness
↑ Cardio-respiratory fitness	↓ High blood pressure	↑ Cardiorespiratory endurance	↓ Anxiety symptoms
↑ Muscular fitness	↓ Stroke	↑ Muscular strength	↓ Depression symptoms
↑ Healthy body mass	↓ Diabetes type II	↑ Health status	
↑ Healthy body composition	↓ Metabolic syndrome	↑ Favourable cardio-vascular risk profile	
↑ Bone health	↓ Colon cancer	↑ Favourable metabolic disease risk profile	
↑ Sleep quality	↓ Breast cancer	↑ Bone health	
↑ Health-related quality of life	↓ Depression		
Additionally in older adults:			
↑ Functional health	↓ Risk of falling		
↑ Cognitive function			
↑, ↓ = strong evidence			
↑ = modest evidence			

week of vigorous-intensity aerobic activity, or an equivalent combination». Furthermore muscle strengthening exercises at least twice a week are recommended. ACSM/AHA [7] and UDHHS [6] have also launched recommendations for older adults: In addition to the general recommendations, older adults should integrate activities that maintain or increase flexibility, and for those at risk of falls balance exercises are recommended. The recommended intensity of activity should take into account the older adult's aerobic fitness. Additionally the UDHHS recommends to older people with chronic conditions that «they should be as physically active as their abilities and conditions allow», if they cannot do 150 minutes of moderate-intensity aerobic activity a week, and that «they should understand whether and how their conditions affect their ability to do regular physical activity safely».

2.3 Physical activity recommendations for children and adolescents

The Swiss recommendations for children issued in 2006 state that adolescents should be active for at least an hour a day and children at the beginning of school age considerably more [8]. All activities of at least 10 minutes duration can be added up. Because optimal development of the child requires a large variety of experiences, movements and stimulations, it is recommended that within or in addition to the daily hour, activities should be carried out several times a week for at least 10 minutes that increase bone strength, stimulate the cardio-vascular system, increase muscle strength, maintain flexibility, and increase agility.

The Swiss recommendations are not identical but nevertheless in line with the US recommendations

issued in 2008 [6], stating that children should be active for one hour or more every day and that most of this daily activity should be either moderate or vigorous intensity aerobic activity. As part of their daily 60 minutes or more they should be active vigorously on at least three days a week and strengthen their bones and muscles also on at least three days a week.

2.4 Physical activity and sports behaviour in adults

The Swiss Health Survey is the most important data source for physical activity behaviour in adults. In the latest survey of 2007, 41% of the population 15 and older were sufficiently active: 32% reported at least three weekly sessions of vigorous intensity activities («trained individuals») and an additional 9% were active with moderate intensity for half an hour on at least five days of the week («active individuals») [8]. A more detailed picture of physical activity behaviour in 2007 according to age groups and five activity levels is given in figure 2. In 2002 this set of indicators has been used for the first time. Since then the proportion of the population meeting the recommendations for vigorous activity increased by 5% while the level of moderate intensity activity remained unchanged.

The Swiss Sports Survey 2008 [9] assessed the sports activities of Swiss adults between 15 and 74 years of age in 2007. The two sports reported most frequently by those 73% of the population who engage in sports regularly or at least sporadically, were cycling / mountain biking (named by 35%)

and walking / hiking (33.7%). With an increase of 3.2% for cycling and 11.1% for walking since the last Sports Survey in 1999, these activities had become substantially more popular in recent years [9]. Figure 3 displays the top ten sports for Switzerland when taking into account also the average number of days reported for the activity. The ranking is established according to the exposure to the respective sport in million person-days per year.

Figure 3
The top ten sports among adults in Switzerland, according to exposure in person-days (percentage of population naming the sport x average number of days they are engaged in this sport) [9]

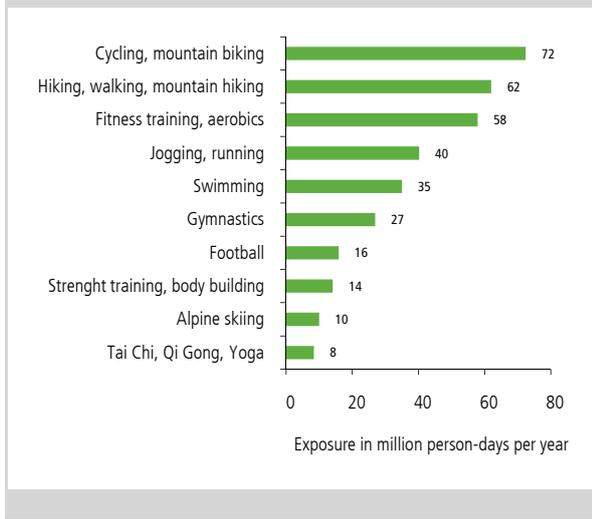
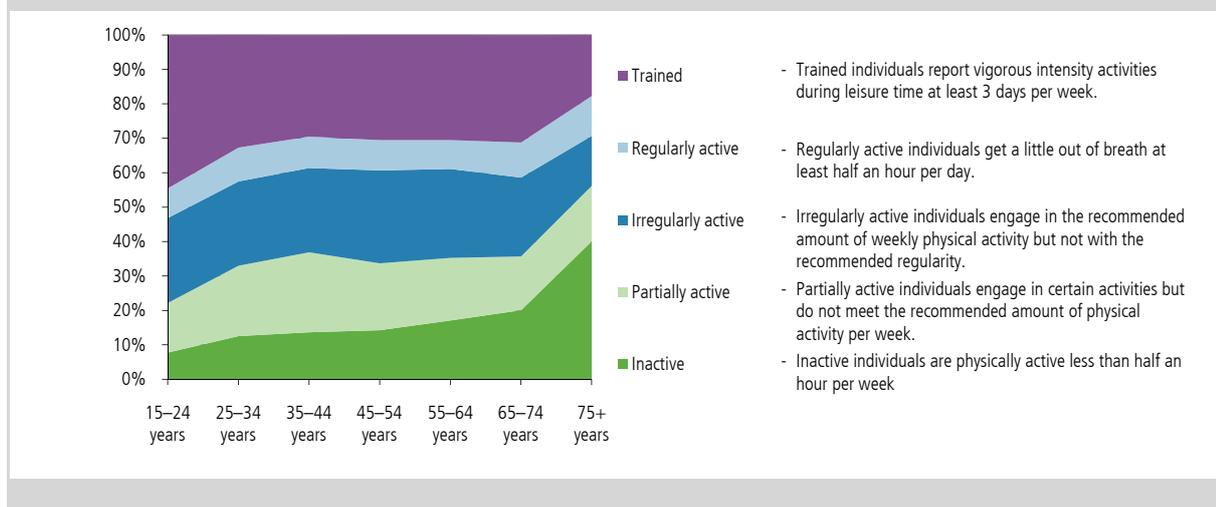


Figure 2
Physical activity levels in Switzerland according to age group (Data source: 2007 Swiss Health Survey) [4]



2.5 Physical activity and sports behaviour in children and adolescents

There is still a lack of representative data on physical activity behaviour of children and adolescents in Switzerland, particularly for children under the age of ten. A detailed overview of the current state of knowledge is given by Martin et al. [8]. Regarding the most popular sports among children and adolescents between 10 and 19 years of age, the Swiss Sports Survey 2008 provides some insights [10]. Among 10–14 year old children 87% declared to be engaged in sports outside school at least sporadically; on average, they named 3.3 sport disciplines, the top sport among boys was football, among girls swimming (Table 2).

For children under the age of ten the Swiss Household Panel 2007 provides the first nationwide data on sport behaviour (Table 3) [11]. In proxy interviews, parents named the main sport [10] discipline of their child. Among boys, football is the clear top sport, among girls it is gymnastics and dance in different variations. It has to be noted that the methodology in the Swiss Sports Survey and the Swiss Household Panel were different and that the data cannot be directly compared.

Table 2
Top ten sports in Switzerland named by those 87% who engage in sport at least sporadically [10]

Boys (10–14 years)		Girls (10–14 years)	
Football, street soccer	69.0%	Swimming	57.1%
Cycling, mountain biking	59.9%	Cycling, mountain biking	56.0%
Swimming	49.5%	Alpine skiing	38.2%
Alpine skiing	38.4%	Football, street soccer	30.8%
Floorball, field hockey	18.9%	Gymnastics	24.7%
Hiking, walking, mountain hiking	16.1%	Hiking, walking, mountain hiking	19.2%
Snowboarding	13.4%	Dancing, ballet	15.4%
Jogging, running	11.2%	Horse riding	14.9%
Gymnastics	10.3%	Jogging, running	14.2%
Basketball, street ball	9.8%	Inline skating	12.1%

Table 3
Most frequently named main sport disciplines in Switzerland, by gender and age [11]

	Boys		Girls				
	5–7 years	8–10 years	5–7 years	8–10 years			
Football	35.4%	Football	37.4%	Gymnastics	31.6%	Gymnastics	16.5%
Gymnastics	23.2%	Gymnastics	9.9%	Gymnastics & dancing	18.4%	Sports dance	9.1%
Swimming	11.1%	Tennis	7.1%	Sports dance	17.3%	Apparatus gym.	9.1%
Karate	7.1%	Athletics	6.6%	Swimming	8.2%	Gymnastics & dancing	8.5%
Judo	5.1%	Judo	4.9%	Tennis	5.1%	Athletics	7.9%
		Unihockey	4.9%				

2.6 Costs of inactivity in Switzerland

In 2001, it was estimated that the direct costs of disease related to physical inactivity total some 1.6 billion Swiss Francs (1.1 billion Euro) each year [12]. In addition, it was calculated that physical inactivity was responsible for 0.8 billion Swiss Francs (0.5 billion Euro) in indirect costs, for 1.4 million cases of disease, and for almost 2,000 death each year [12]. These estimations were based on levels of physical activity assessed in a smaller survey in 1999 that later proved to be too optimistic with only 37% of the population insufficiently active [13]. Adjusting the calculations to the prevalence of inactivity assessed in the Swiss Health Survey 2002 (64% of the population insufficiently active), inactivity causes direct treatment costs of 2.4 billion Swiss Francs (1.6 billion Euro), 2.1 million cases of illness and 2,900 premature death each per year.

2.7 Becoming more active: basic principles

The importance of physical activity in the prevention of chronic disease has been recognised in many countries. In Switzerland a first base document on health enhancing physical activity was launched already in 1999 and it was updated regularly [4,14]. The document briefly summarises some of the basic principles that should be kept in mind to minimise injury risk when people are encouraged to be more active: If previously inactive or sporadically active individuals are addressed, activities requiring little in the way of equipment and practice, that can be practiced with moderate intensity and that have low injury risks such as hiking, walking, cycling or swimming should be recommended. For those who plan to start with

vigorous activities such as endurance training, it is important to start gradually. And finally, people who are already very active should carefully plan their training sessions, competitions and recovery phases in order to minimise the risk of traumatic or overuse injury [4]. It is thus well recognised that attempts to improve population health through more physical activity should always include strategies to minimise the burden of disease because of activity-related injuries.

3. Injury prevention

3.1 Injuries and health

Accidents resulting in injuries or even death are a huge public health problem. Even though there have been great efforts over decades to prevent injuries almost one million non-occupational accidents resulting in injury or death are counted every year in Switzerland. 100,000 individuals are injured in road accidents, 300,000 during sports activities and 600,000 at home and while pursuing a hobby. 90,000 individuals are injured severely resulting in hospitalisation, 3,000 remain disabled for the rest of their life. Some 2,000 people are killed each year through a non-occupational accident: 330 in road accidents, 1,500 in the home environment and about 140 during sports activities (Table 4, p. 43) [15].

3.2 Incidences of fatalities and injuries in Switzerland

overview of the estimated number of people among Swiss residents injured, disabled or killed in the year 2006 in a non-occupational accident.

In Switzerland data sources on non-occupational accidents are analysed, integrated and published by the bfu. An overview of definitions and terminology is given in table 4. The most important data sources are the statistics on non-occupational accidents of the Central Office for Statistics under the Federal Law for Accident Insurance. This insurance also covers non-occupational accidents in 4 million individuals between 17 and 64 years of age being employed for at least 8 hours a week. For other population groups (e. g. children, students, individuals doing family work or being retired) accident numbers are estimated based on the insurance data or on specific surveys [16,17]. For fatal accidents, also the national statistics on the causes of death is used. Table 5 gives an

Table 4
Definitions of key terms and classification of accidents and injuries used in statistics in Switzerland (definition of accident see [15], of injury see [16])

Accidents and injuries

In Switzerland, experts in injury prevention define an accident as a sudden unintentional impact of an unexpected external factor on the human body, affecting a person's physical, mental or psychological health or resulting in death.

An injury is defined as a bodily lesion at the organic level, resulting from acute exposure to energy (this energy can be mechanical, thermal, electrical, chemical or radiant) in an amount that exceeds the threshold of physiological tolerance. In some cases (e.g. drowning, strangulation, freezing) the injury results from an insufficiency of a vital element.

Classification in Swiss statistics

Accidents

- Occupational
- Non-occupational

- > Road traffic accidents
- > Sports accidents
- > Home and leisure accidents

Consequences of accidents

- Fatality
- Injury
 - > Slightly injured: not hospitalised
 - > Moderately severely injured: hospitalised for 1 to 6 days
 - > Severely injured: hospitalised for 7 days or more

Table 5
Number of Swiss residents injured, disabled or killed in a non-occupational accident in 2006 [15]

Sector	Total (incl. light injuries)	Moderately severely injured ¹	Severely injured ²	Disabled	Fatalities
Road traffic	94 000	5 150	8 070	800	333
Sports	299 000	15 370	9 540	253	136
Home and leisure	607 000	20 090	26 930	2 086	1 500
Total	1 000 000	40 610	44 540	3 139	1 969

¹ hospitalised for 1–6 days

² hospitalised for 7 or more days

More than 70% of the 1,969 fatal accidents in 2006 occurred in seniors aged 65 or older and the vast majority of these accidents happened in the home environment (Table 6). Overall, more than three quarters of the fatalities in the home environment are caused by falls – among children and young people by falling down from a higher level and among the elderly by falling or stumbling on the ground level. The majority of the fatal accidents in sports are attributable to mountain sports (mountaineering and hiking), followed by winter sports and water sports (Table 6). About three quarters of the individuals dying in road traffic accidents were travelling in a motorised vehicle, about 16% were pedestrians and 8% cyclists [15].

Figure 4 gives an overview of the number of persons injured in different age groups in the year 2006 per 10,000 inhabitants, as estimated by the bfu [15]. In the home environment, most injuries occurred while moving around in the house or garden (30% of all injuries), during play (14%) or housework (8%). The most common accidents leading to injuries were falls or tripping on level ground (29%), cutting (18%), falls from a height (12%) and falls or tripping on the stairs (11%). In road traffic accidents, 13% of all injured individuals were cyclists and 9% were pedestrians. The number of severely injured and killed pedestrians

has decreased by about two thirds since 1980, while the number of slightly injured individuals has remained stable. For cyclists, the number of severely injured or killed persons has decreased by about one third while the light injuries increased by about 70% in the same time period. Sports injuries are presented below in some more detail.

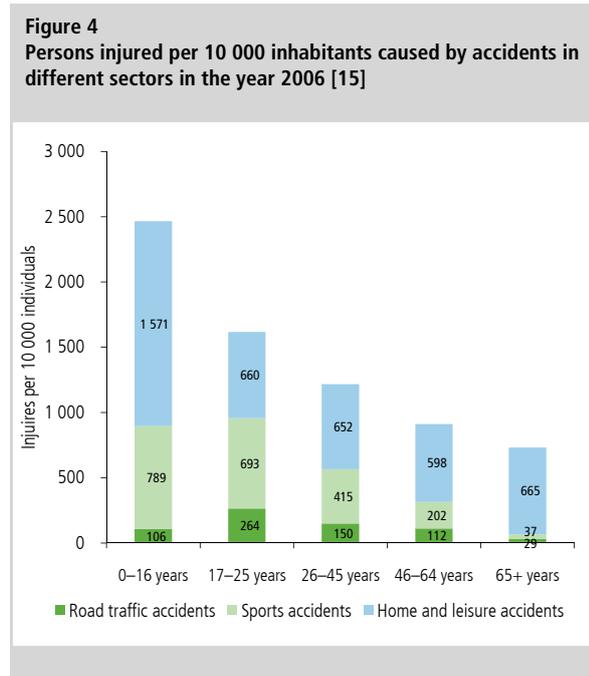


Table 6
Fatal non-occupational accidents in Switzerland in the year 2006, by sector and age group [15]

Age	Absolute numbers of fatalities			Fatalities per 1 mio inhabitants		
	Road traffic	Sports	Home & leisure	Road traffic	Sports	Home & leisure
0–16	25	11	21	18	8	15
17–25	70	15	11	87	19	14
26–45	77	34	54	34	15	24
46–64	63	45	134	34	24	71
65+	98	31	1 280	81	25	1 052
Total	333	136	1 500	44	18	200

3.3 Sports injuries

If all injuries are taken into account (i. e. also light injuries) most events occurred during football (18% of all sports injuries), skiing (15%), cycling (11%; road traffic accidents not included), snowboarding (8%), inline skating (3%) and swimming (3%). The ranking of these absolute numbers does not take into account the exposure of the population to the different sports. Table 7 lists the «Top-20» sports regarding the average number of injured individuals between 2003 and 2007.

3.4 Costs of accidents and injuries

Every year, accident insurances have to compensate for 7.8 million work days lost. It is estimated that the costs of non-occupational injuries are about 12 billion Swiss francs (8 billion Euros) annually (including health care costs and loss of productivity). Some 45 percent of the costs are caused by road traffic accidents, 15 percent by sports activities and 40 percent by accidents in the home and during leisure time activities [18].

Table 7
Average number of injured individuals between 2003 and 2007, by sports [15]

Average number	Sports	Injured individuals
1	Football	53 800
2	Downhill skiing incl. touring	44 600
3	Cycling, mountain biking (excl. traffic)	32 800
4	Snowboarding	25 300
5	Swimming, bathing	9 900
5	Sledging	9 900
7	Inlineskating	9 300
8	Volleyball	8 700
9	Mountain hiking Hiking (excl. mountaineering)	8 400
10	Apparatus gymnastics	8 100
11	Running, jogging	7 200
12	Ice-hockey	6 500
12	Land, roller and unihockey	6 500
12	Equestrian sports	6 500
15	Basketball	5 900
16	Handball	5 200
16	Martial arts	5 200
18	Gymnastics, fitness training, aerobics	4 000
19	Athletics	3 800
20	Tennis	3 400
21	Remaining sports or games	38 800
Total		303 800

3.5 Accident and injury prevention

In Switzerland, there are two institutions with a legal mandate that are active in injury prevention on the national level:

- **bfu – Swiss Council for Accident Prevention.** bfu was formed in 1938 and transformed into a private foundation in 1984. It has a legal mandate to prevent non-occupational accidents in the areas of road traffic sports, home and leisure and to coordinate prevention measures of all players in the field. The foundation is independent of economic and political interests and it is financed by a supplementary charge on the insurance covering non-occupational accidents. The objectives and approaches of injury prevention are listed in the strategy 2011–2015 [19]: In the prevention of road traffic accidents bfu supports the national objective to significantly reduce the number of people killed or injured until 2015. Table 8 gives an overview of severe injuries and fatalities in the sports disciplines that have been identified as priority areas. The objective of injury prevention in the home environment is an overall reduction of severe injuries and fatal accidents among the elderly by 8% even with an aging population. The approaches chosen are based on sound scientific grounds and

generally include measures to influence policy making, to make infrastructure and products safer and to educate the public to reduce risk behaviour and use protective equipment.

- **Swiss Accident Insurance Fund (Suva).** Suva is an independent, non-profit company formed in 1918. Its business activities are based on the accident insurance law. Suva insures around 110,000 companies and 2 million employees and unemployed people respectively against the consequences of accidents and occupational diseases. It is also responsible for military insurance by government mandate. Its range of services encompasses prevention, insurance and rehabilitation. One of the four business areas of Suva is the prevention of non-occupational accidents, using mainly wide-scale campaigns and individual advice and training.

Table 8
Number of people injured severely or killed in the priority areas of sports injury prevention in the year 2006 [15]

	Moderately severely injured ¹	Severely injured ²	Fatalities
Football	1 120	2 300	0
Downhill skiing (incl. touring)	3 480	2 840	11
Snowboarding	1 320	490	7
Cycling, mountain biking (road traffic excluded)	1 210	940	1
Bathing, swimming	260	70	15
Mountain sports	1 330	900	50

¹ hospitalised for 1–6 days

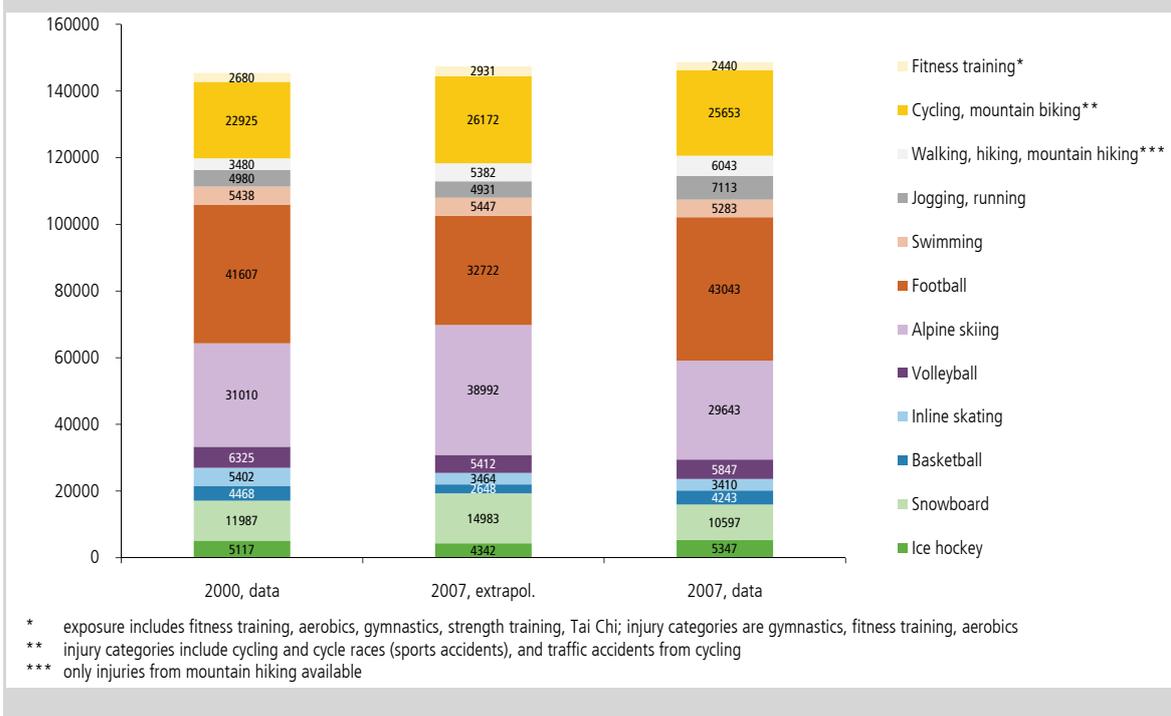
² hospitalised for 7 or more days

4. Combining exposure to sports activities and sports injury data in Switzerland

It has been outlined above that the most popular sports in Switzerland are walking/hiking, cycling/mountain biking as well as fitness training/aerobics. The exposure to these sports has increased substantially in recent years [9]. The injury risk for these sports is low [20]. Even with rising levels of physical activity it could be that the total of activity-related injuries in a population does not increase because of shifts from higher-risk to low-risk sports. This mechanism was tested with data from the Swiss Sports Survey 2008 [9] and the statistics on non-occupational accidents compiled by bfu (specific analysis for the age group addressed by the law on accident insurance (17–64 years); Steffen Niemann, personal communication). The ten sports with the highest exposures in

person-days in 2007 (Figure 3, p. 40) and the ten sports with the highest absolute numbers of accidents in 2,000 (a total of 15 sports) along with the changes in exposure to these 15 sports between 1999 and 2007 were used to extrapolate the expected total number of sports accidents in 2007 [21]. Within these eight years, the total exposure to these 15 sports increased by 10.0% when the population growth of 3.7% had been taken into account. According to the extrapolation the expected number of accidents increased by only 1.6%. The real number of accidents compiled by the national statistics actually increased 2.2% (Figure 5). It seems thus possible that physical activity behaviour can be improved substantially while the number of accidents only increases under-proportionally or even remains stable. Overall, the extrapolation met the real numbers remarkably well. For some sports the two figures were almost identical while for other disciplines

Figure 5
Number of injured in the most prevalent sports and the top sports regarding absolute numbers of injuries in 17–64 year olds in Switzerland, according to national statistics for non-occupational accidents and to an extrapolation. Assumption for extrapolation: Same exposure regarding days per year and duration of activity in 2007 as in 2000.



they differed largely (Figure 5, p. 47), indicating the necessity to study this question in more detail.

5. Aims of this report

With a view on developments of injury risk, there are questions about the optimal way of promoting physical activity. Is it inevitable that more active individuals have more injuries? Or could it be that through a shift towards more low-risk activities an overall increase in physical activity levels could result in an under-proportional increase or even a decrease in the number of injuries? Under which circumstances can physical activity promotion as such prevent injuries?

A broad perspective on these issues cannot only consider the relationship between physical activity and sports-related injuries, but injuries from all causes. It is possible for example, that active people suffer from fewer injuries in other contexts because of their enhanced fitness. An important question is whether, overall, an active population will have more or less injuries than an inactive population.

Another focus should be on physical activity promotion programmes. The question here is how they must be organised that previously inactive individuals who increase their levels of physical activity will not at the same time increase their injury risk.

There are specific groups such as athletes in sports or army trainees that suffer from injuries more frequently than others because they are very active. This has been recognised and measures to counteract injury risk in these groups have been tested. The question is if such interventions are effective and whether they can be generalised to larger population groups.

In view of these considerations this report will give an overview of the scientific literature by focussing on the following research questions:

- a) What are the associations between habitual physical activity behaviour as well as changes in physical activity and the risk of injuries in different age groups of the general population?
- b) What are the effects of training programmes on the risk of injuries in specific population groups?
- c) How is the current state of knowledge regarding physical activity promotion and injury prevention integrated into national guidelines and recommendations in other countries?

III. Methods

In preparation for an update of the recommendations for health-enhancing physical activity, the US Department of Health and Human Services (USDHHS) has updated and completed the evidence for the effects of physical activity on health [6]. The respective report served as the starting point for the elaboration of the work presented here, particularly the sections G6 on functional health (falls and fall-related injuries in older adults) and G10 on adverse events (musculoskeletal injuries). The reference lists of the report were used to identify specific papers that were analysed in more detail.

In a second step literature data bases were searched for reviews and single papers that had been published between 2007 and 2009 and for earlier European publications on the topics discussed in the Advisory Committees report. Search terms such as physical activity, exercise or sports for exposure and injuries, accidents, falls or fractures for outcomes were used. The option of «related articles» was used and reference lists of identified papers were screened.

In a third step, the reference lists were completed by reports and other forms of grey literature from Switzerland. These were identified from the personal knowledge of the authors and from recommendations of other national experts.

In the Advisory Committee's report [6] the section G9 on youth, however, did not cover adverse events specifically for children or adolescents. Thus the material presented for the chapter on children

and adolescents in this work is based only on searches described above. Additional search terms such as «risk factor» or «determinants» and «school-injuries» were used.

In a fourth and final step, selected institutions and experts from other countries were asked to comment on a first version of the report. One further data source was identified based on their recommendations.

IV. Results

1. Variables and methods of data collection

The majority of the literature reviewed uses the term «injury» and not «accidents» as an outcome; from a public health perspective, this seems appropriate. However, usually studies do not distinguish between traumatic injuries and injuries resulting from overuse. In accordance with its mission the primary focus of the bfu are traumatic injuries.

Thus, studies that did not distinguish between traumatic and overuse injuries were included in this literature overview. However, studies that explicitly investigated only overuse injuries (for example stress fractures in athletes) were not included.

In the literature, a variety of measures for physical activity is used. The same is true for measures of accidents and injuries. Table 9, p. 51 gives an overview of the respective variables used in different studies. The purpose of this list is to give an impression about the wealth of predictor and outcome variables used in the field. Given the large variety of measures used, it is not surprising that the literature is rather heterogeneous and that it is often difficult to compare studies.

Furthermore, methods for the assessment of physical activity and incidence of injury varied across studies. An overview of methods used is given in table 10, p. 51.

Table 9
Examples of predictors and outcome variables found in the literature

Observational studies: predictor variables for «level of physical activity»

Habitual physical activity	- Total physical activity - Vigorous intensity activities - Moderate intensity activities
Physical activity by mode	- Leisure time physical activity - Occupational physical activity - Domestic physical activity
Sports participation	- Frequency or duration - In club or not in club - In specific sports
Components of «fitness», e. g.	- Cardio-respiratory fitness («Endurance») - Leg power - Walking speed
Components of «coordination», e. g.	- Balance measures - Reaction time

Intervention studies: Elements of the «physical activity, exercise or training programmes»

General programmes, e. g.	- Calisthenics - Warming up
Specific activities, e. g.	- Walking - TaiChi - Wobble board training - Strength training for specific muscle groups
Combined programmes	- Several physical activity elements combined - Physical activity elements in combination with other injury or fall prevention measures

Outcome variables: «Incidence of accidents and injuries»

Type/severity of injury	- Any injury - Injury requiring medical treatment - Injury resulting in hospitalisation - First time / repeated injuries
Injuries according to context	- Sports-related injuries - Injuries related to recreation - Injuries related to other causes - School injuries
Specific (sports) injuries	- e. g. ankle ligament sprains - Fracture of the upper arm
Falls in older adults	- Falls to the ground - Injurious falls
Fractures in older adults	- All osteoporotic fractures - Osteoporotic hip fractures - Other osteoporotic fractures - Fractures from falls / from other causes
Fractures in children	- All fractures - All fractures of the upper extremities - Specific fractures of the upper extremities (e. g. wrist)

Table 10
Assessment of physical activity and incidence of injuries

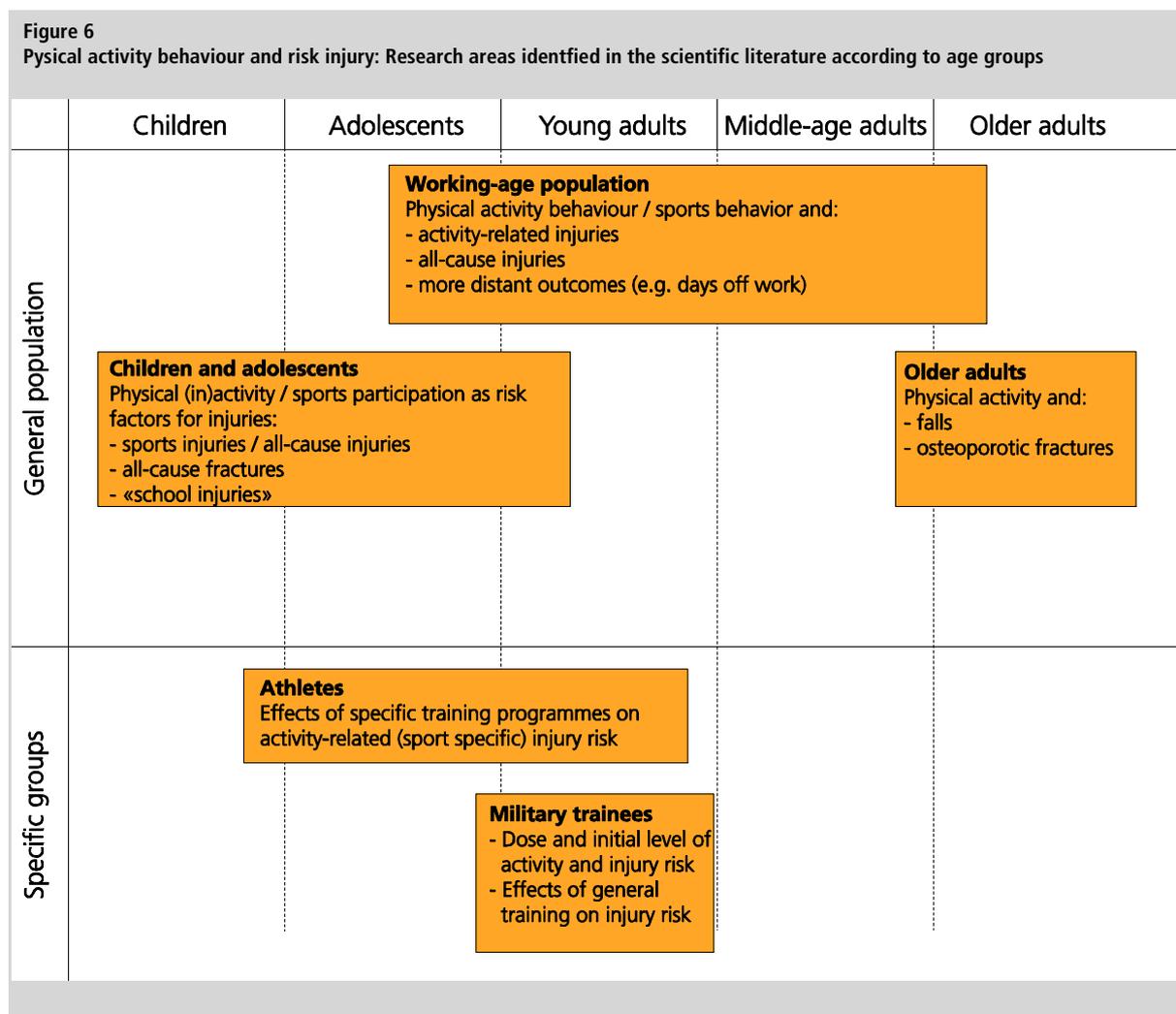
Assessment of «physical activity»

- Retrospective self-report, questionnaire
- Retrospective parental report, questionnaire
- Self-report, diaries
- Objective measures of «fitness» e. g. for cardiorespiratory fitness
- Objective measures of «coordination»; e. g. different «balance tests»
- Objective measures of physical activity behaviour: accelerometry

Assessment of «incidence of injury»

- Retrospective self-report
- Retrospective report by parents or teachers
- Prospective self-report
- Prospective report by parents or teachers
- Hospital records
- Insurance records

The review of the literature revealed that the overall question investigating the association between physical activity behaviour and all-cause injury risk is hardly ever addressed as such. But a variety of studies could be identified that investigated more specific research questions. In fact, the topics addressed differ remarkably over the life span. Figure 6 gives an overview of the identified research areas according to age groups of the general population as well as specific groups. This report is organised along these research areas in the different population groups.



2. Working age population

2.1 Activity-specific injury risks

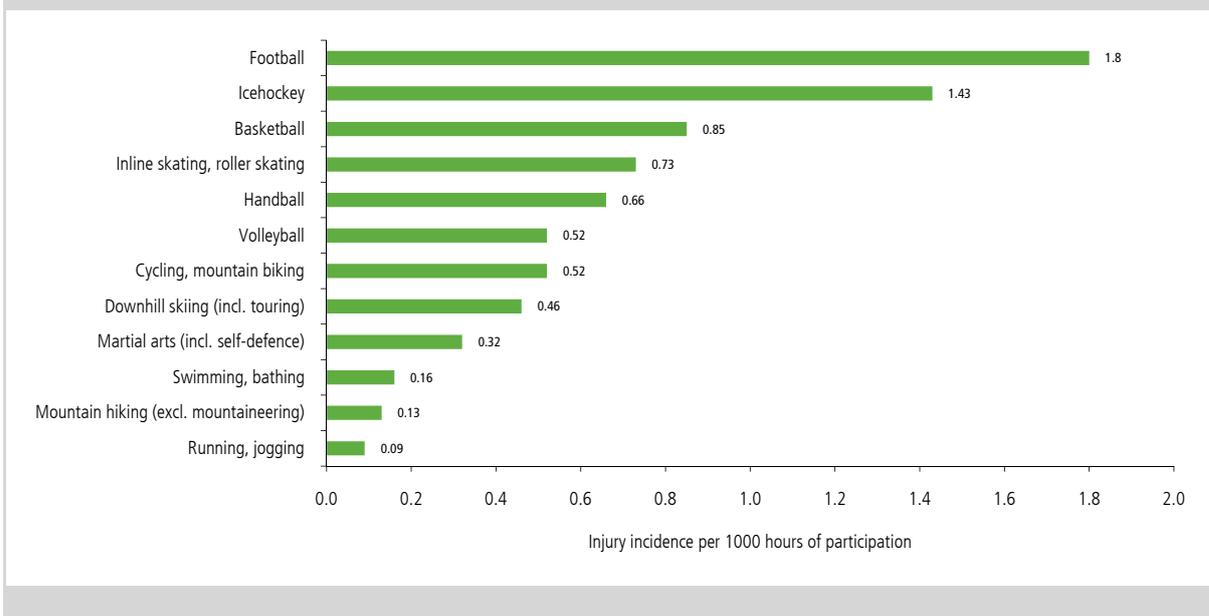
An overview of sport- and activity-specific injury incidences is not the focus of this report. Therefore this topic is not discussed in detail but presented only briefly. There are many statistics compiling activity- or sports-specific injury rates, however, not many studies have assessed exposure times and present incidences of injury per hours of exposure to a specific activity. Furthermore, the majority of data was collected among athletes and there are only few studies conducted among the general population.

An overview of injury incidences for different sports, usually assessed among teams of athletes, is given in the report of the Physical Activity Guidelines Advisory Committee [2]. Often it is distinguished between collision sports (e. g. American football, ice hockey, wrestling), contact

sports (basketball, football), limited-contact sports (baseball), and non-contact sports (running, swimming). Generally, injury risk is higher for collision or contact sports compared to the other two categories.

In Switzerland, first attempts were undertaken to estimate exposure to different sports for the general population in the Swiss Sport Survey 2008. These exposure times were linked with the numbers of injuries requiring medical treatment (estimations based on the statistics on non-occupational accidents of the Central Office for Statistics under the Federal Law for Accident Insurance) yielding first estimates of injury incidences per hours of activity for specific sports (Figure 7). For adolescents, there has been specific incidence data since the 1990-ies (chapter IV.4.1, p. 65).

Figure 7
Incidences of injuries in the general population in Switzerland requiring medical treatment per 1000 hrs of participation in selected sports. Estimates based on exposure times assessed in the Swiss Sports Survey 2008 [9] and injury numbers from the national statistics [15]



Regarding the general population, there is a well conducted study from Finland, assessing not only the risk of sport-specific injuries, but also injury risks of activities of daily living [20]. A cohort of 3,657 randomly selected individuals of 15- to 74-years of age was followed for one year. Study participants recorded all their physical activities and registered all acute and overuse injuries that occurred during these activities. They were interviewed by phone every four month. Three levels of injuries were defined: Level I: injury or pain only affecting duration or intensity of activity; level II: injury or pain resulting in missing at least one session of activity; level III: Injury or pain resulting in at least one day off work. The injury incidence for all levels was relatively low, (ranging from 0.19 to 1.5 per 1,000 hours of exposure) in commuting and lifestyle activities such as home repair or fishing, and in some sports such as golf, dancing or cross country skiing. The risk was clearly higher in contact and team sports, squash, and orienteering (ranging from 6.6 to 18.3 per 1,000 hours of

participation). Table 11 gives the injury risks for selected activities.

The injury incidences for specific sports in the two studies presented above vary to some extent. However, given the different injury definitions, assessments methods and study designs, this is not a surprise. For some sports, the values are in a comparable order of magnitude.

Table 11
Selected examples of activity-specific incidences of all injuries adapted from [20]

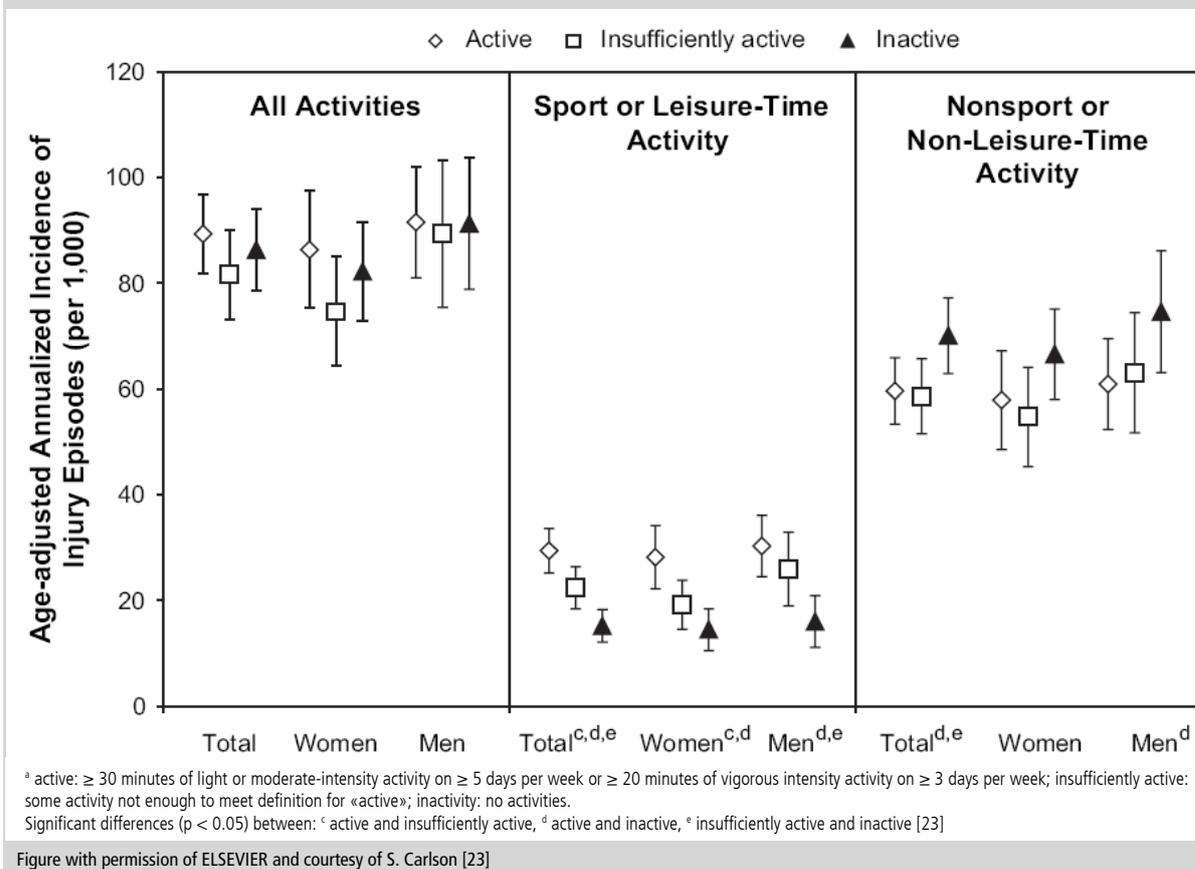
	% respondents reporting activity	Number of injuries per 1,000 hrs of activity (95% conf. interval)
Squash (highest injury risk)	0.9	18.3 (11.4-29.4)
Orienteering	1.0	13.6 (5.6-32.6)
Football	6.0	7.8 (6.3-9.7)
Ice hockey	3.0	7.5 (5.8-9.8)
Inline skating	8.6	5.0 (3.9-6.6)
Downhill skiing	6.1	4.1 (3.0-5.7)
Running	24.4	3.6 (2.9-4.4)
Aerobics, gymnastics	20.3	3.1 (2.5-3.9)
Cycling for sport or recreation	51.3	2.0 (1.7-2.5)
Nordic walking	11.3	1.7 (1.1-2.7)
Cross country skiing	24.8	1.7 (1.3-2.2)
Walking for recreation	79.5	1.2 (1.0-1.3)
Gardening	83.0	1.01 (0.89-1.15)
Dancing	58.5	0.7 (0.55-1.01)
Home repair	57.0	0.54 (0.46-0.64)
Cycling for commuting	33.0	0.48 (0.34-0.68)
Golf	1.9	0.3 (0.07-1.12)
Walking for commuting	62.0	0.19 (0.15-0.25)

2.2 Association between levels of physical activity and injury risk: observational studies

There are numerous studies investigating the association between type or dose of physical activity and incidence of activity-related injuries in populations of athletes or military trainees. However, there are only very few studies addressing the association between habitual levels of physical activity and activity-related injuries or injuries from all causes in the general population. In fact, the experts compiling the evidence on possible adverse effects of elevated levels of physical activity for the Physical Activity Guidelines Advisory Committee Report [2] identified two single studies, both conducted by the same

research group. The experts summarised: «Although the risk of activity-related injury is greater among persons who are more active, the risk of other types of injuries (e. g., motor vehicle, work-related) may be less, making the overall risk of injury for active people no greater than that for sedentary people. Only two population-based studies have examined this issue. One reported that people who ran or participated in sports activities were about 50% more likely to report an injury (activity-related or not) than people who reported walking for exercise or were sedentary [22]. The other reported no significant differences in overall injury rates (activity-related or not) between inactive people, irregularly active people, and people who met current recommendations for physical activity [23]. More studies of this type are

Figure 8
Age-adjusted annualised incidence (with 95% confidence intervals) of self-reported injury episodes (per 1,000) by levels of leisure-time physical activity^a, National Health Survey, United States 2000–2002



needed, but it is possible that regular physical activity may cause some injuries and prevent others, and that physically active people may have no more injuries than sedentary individuals.» [2, part G, section 10, p. 3].

In one of these studies [23] US National Health Interview Survey data from 2000 to 2002 were analysed. The authors compared self-reported incidence of all-cause and activity-related injuries reported retrospectively with three levels of leisure-time physical activity (sufficiently active according to recommendations, insufficiently active, inactive). Sufficiently active individuals had more injuries from sports or other recreational activities and inactive subjects had more injuries from other causes. Overall, incidences of all-cause injuries did not differ by activity level (Figure 8). This overall pattern was the same for both sexes, for individuals with low and high incomes and for individuals with normal weight or overweight respectively. Among 18–34 year olds, active individuals had more injuries requiring medical attention than inactive subjects, while among the oldest age group of 65+ inactive people had more of these injuries than the active group.

Among 25–34 year olds, sufficiently active individuals had more all-cause injuries than insufficiently active subjects; and for educational level, there were some differences between activity groups regarding incidence of all cause-injuries but no consistent patterns.

In the second paper [22] participants of a large epidemiologic cohort study reported activity-related traumatic or overuse injuries retrospectively for the preceding 12 month. Injury risk was assessed in relation to cardio-respiratory fitness at

enrolment into the study and in relation to activity duration and group (sedentary, walking, running, strenuous sport) during the 12 month report period. The risk of activity-related injuries increased with higher fitness levels and increasing activity duration in runners. However, among walkers and participants in other sports, longer duration of activity was not associated with increased injury risks. Furthermore, there was no association between injuries from other causes and activity group or duration respectively (Odds ratios mostly <1 but not significant).

Further analyses of the same data revealed that in the study population 83% of all injuries were activity-related, and that two thirds of these injuries occurred in the lower extremities [24]. Walking or running more than 20 miles per week was a strong predictor of lower extremity injuries requiring medical treatment [25]. The authors concluded that «walking at a brisk pace for 10–20 miles per week accumulates adequate moderate-intensity physical activity to meet national recommendations while minimizing the risk for musculoskeletal lower extremity injury. Clinicians may use this information to provide appropriate injury prevention counselling to their active patients».

A British study [26] not included in the USDHHS-Report [2] investigated risk factors for injury morbidity from all causes in 18–64 year olds. Rates of injury declined with age while rates of longstanding illness from injury increased with age. Participation in vigorous exercise was a risk factor for any injury (including occupational injuries) with a clear dose-response relationship between the number of days with vigorous exercise and any injury. However, participation in vigorous exercise

seemed to be protective for longstanding disability. Participation in moderate intensity activities or levels of total physical activity had not been assessed.

No further international studies published after 2006 addressing the association between physical activity levels and injuries in the general population could be identified when searching the literature data bases.

It has to be noted that with the exception of the association between fitness level and injury risk [22], physical activity behaviour and injuries were assessed simultaneously. Because the retrospective reporting period for injuries is usually longer than for physical activity behaviour, reversed causality cannot be excluded, i. e. that an earlier injury determined physical activity.

2.3 Levels of physical activity and injuries in Swiss population surveys

Nevertheless, further insights into this field are provided by the Swiss HEPA survey 1999 [13] and secondary analyses of the Swiss Health Survey data 2002 [27] and the Swiss Household Panel data of the years 2000–2007 [28], respectively.

In the Swiss HEPA survey dating back to 1999 (N=1,535) incidences of self-reported traumatic injuries for different levels of physical activity had been estimated for the first time [13]. Among those who met the recommendations for vigorous activities (trained individuals) 9.8% reported an injury from any cause for the year preceding the telephone interview. The respective figures were 9.3% for those meeting the minimum recommendation of half an hour of moderate

intensity activity per day (active individuals) and 7.8% for subjects not meeting any of the two recommendations. There were no significant differences between the injury incidences, suggesting that these results are in line with the US study described above [23]. When exposure was taken into account injury risk was highest among the least active group. For sports accidents alone there were no differences between the three groups either with 3.2% of the trained, 2.7% of the active and 3.1% of the inactive individuals reporting an injury.

Using data from the Swiss Health Survey 2002 (N=19,706) Lamprecht & Stamm [29] investigated the association between the incidence of traumatic injuries related to sports and recreational activities and levels of habitual activities. There was a dose-response relationship between level of physical activity and injury risk with a 3.5-fold risk among the most active group compared to the inactive group. However, the proportion of injuries requiring medical treatment was higher among inactive than among the most active individuals (73% vs. 57%), suggesting that activity-related injuries may be more severe among those who are active only sporadically. This hypothesis was supported by the fact that after an activity-related injury inactive individuals were absent from work for 22 days on average, the middle activity group for 10 days and the most active individuals for only 6 days. The total of all workdays lost because of activity-related injuries was only some 20% higher among the most active individuals compared to inactive individuals and even 7% lower than in the middle activity group.

A cross-sectional analysis of the Swiss Household Panel data from 2000–2007 (9864 individuals

yielding 35,000 observations) assessed the association between habitual moderate intensity physical activity and disability days (the number of days unable to carry out the usual activities such as work or housework due to a health problem) in the employed population [28]. The cause of the health problem could be attributed either to illness or an accident. There was no relationship between the level of physical activity and the number of disability days due to an accident. Those who were active seemed to have more disability days due to sports-related accidents while inactive individuals reported more disability days due to an occupational accident. Overall, a U-shaped relationship between the number of days engaging in moderate intensity physical activity and the number of disability days could be observed. Individuals not engaging in any activity or being active for five days or more days reported more disability days than those who were active for one to four days. The same U-shaped relationship emerged for disability days due to illness.

The surveys presented above used cross-sectional data analysis, assessing physical activity behaviour and incident injuries retrospectively: Thus, injuries occurred in general before the time period for which the activity levels had to be reported. With such study designs it can not be excluded that causality is reversed and injury determines the level physical activity.

2.4 Injuries in intervention studies to increase levels of physical activity

Intervention studies in this age group are mainly conducted to increase levels of physical activity, often in order to improve specific health outcomes (e. g. blood pressure) and not to reduce the risk of

injury as in older adults. In such interventions activity-related musculoskeletal injuries are undesired side effects, which are reported in some of these studies. However, the main outcomes of interest are either changes in physical activity behaviour or the addressed health outcome.

It is thus not surprising that the evidence on the relation between physical activity doses and injury rates compiled in the Physical Activity Guidelines Advisory Committee Report [2] for young to middle-age adults is weak. Overall, musculoskeletal problems seem to be quite common in exercise interventions, particularly if vigorous activities are promoted. In older adults, the incidence of injuries in the intervention group in a programme recommending moderate intensity activities was not higher than in the control group [30]. Furthermore, it seems that injuries occur predominantly during the first weeks of an intervention programme [31]. These findings support the well known principle that exercise programmes should be introduced gradually in order to prevent activity-related injuries.

No additional intervention studies could be identified through a search of the literature data bases assessing not only activity-related musculoskeletal injuries but also injuries from other causes in this age group.

In summary, the US Advisory Committee concludes that «reports from experimental studies suggest that frequency, duration, and intensity all contribute to the risk of physical activity-related adverse musculoskeletal events, that a substantial increase in activity level leads to high rates of musculoskeletal problems, and that moderate intensity physical activity appears to have low (but

not precisely measured) injury rates» [2, part G, section 10, p. 18]. Regarding the methodologies used in these studies, it is stated that «Although substantial numbers of clinical trials with physical activity as an exposure have been done in recent years, information about musculoskeletal injuries incurred during the trials and their relation to dose of activity is sparse. Comparison among studies is difficult because the assigned activity, outcome measures, period of study, and level of detail about injuries differ markedly» [2, part G, section 10, p. 17].

2.5 Working-age population: Evidence in brief

There is good evidence for large differences of injury risks within specific sports or activities.

There is some consistent evidence that higher levels of physical activity, in particular regarding intensity, are related to higher numbers of activity-related injuries in the general population. There are some suggestions that activity-related injuries could be more severe among those who are not active on a regular basis. There are indications from some studies suggesting that higher levels of physical activity are not necessarily related to increased risks of all-cause injuries.

There is some evidence from exercise intervention studies suggesting that frequency, duration, intensity, and type of activity all contribute to the risk of physical activity-related injuries, and that moderate intensity physical activity appears to have low (but not precisely measured) injury rates.

3. Older adults

Among older adults, two outcomes of interest dominate: Falls and osteoporotic fractures. The quality of the studies and the evidence for the relationship between levels of physical activity and the risk of injuries are the best compared to the other research areas commented in this report.

The evidence on the risk of falls is based on numerous intervention trials, while estimations on the risk of osteoporotic fractures are mainly based on large observational cohort studies. Most of these observational studies were conducted over a relatively short follow-up period and thus assessed physical activity only at baseline. However, there are a few long-term studies investigating also the effects of changes of physical activity behaviour on fracture risk.

3.1 Risk of falls in older adults

The Physical Activity Guidelines Advisory Committee Report [2] included eight systematic reviews or meta analyses (Figure 9, p. 60) for the assessment of the association between physical activity and reduction of falls in older adults at increased risk [32–39].

The characteristics of the interventions compiled in these included reviews are summarised as follows: «Most of the interventions reviewed included a pattern of physical activity that involves 3 times per week of balance and moderate intensity muscle-strengthening at 30 minutes per session, with additional encouragement to participate in moderate-intensity walking activities 2 or more days per week for 30 minutes a session. It was difficult to ascertain an optimal dose for Tai Chi, as

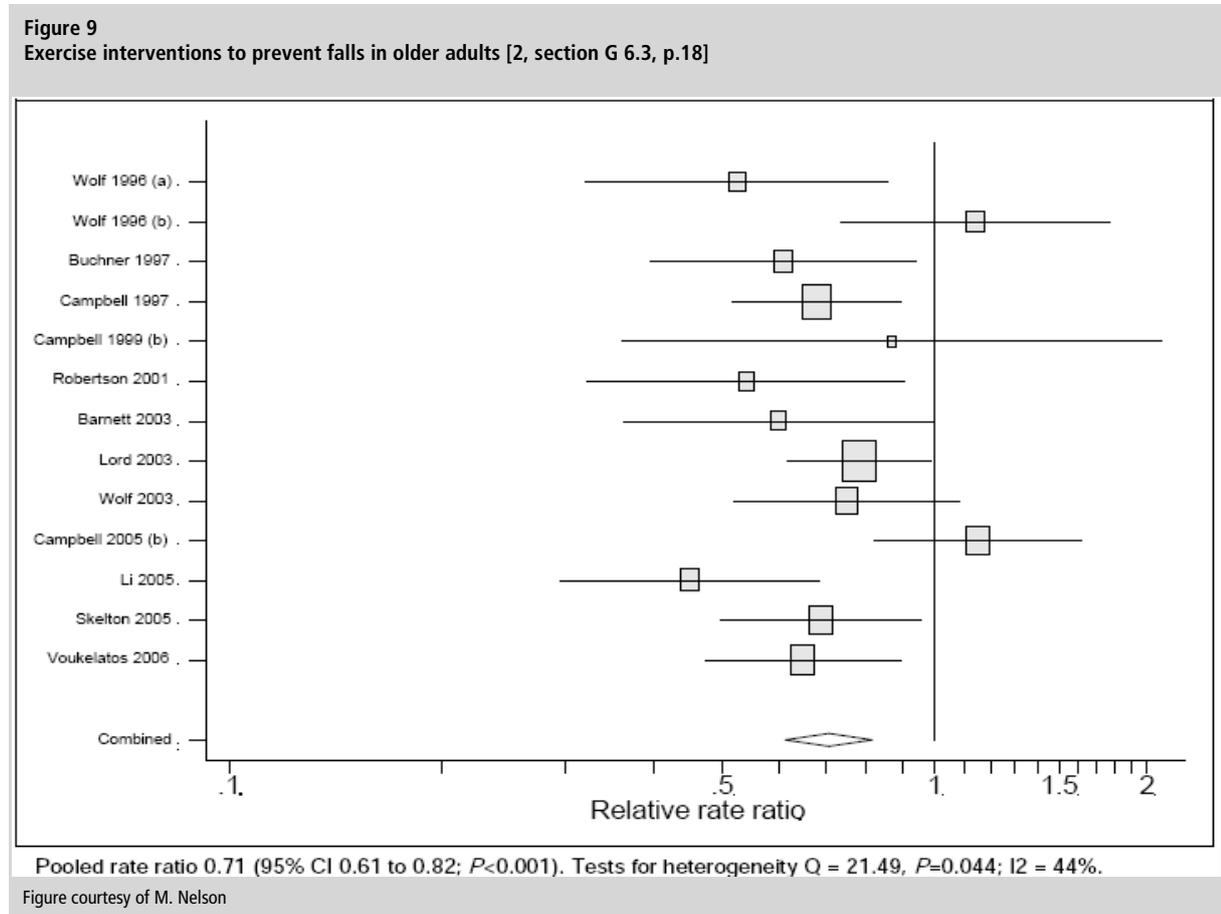
risk reduction was seen in one trial with as little as 1 hour per week, whereas other trials had greater frequency (e. g., 3 days per week)» [2, part G, section 6, p. 16]. It is stated that many studies failed to demonstrate effects of physical activity interventions on fall risk (or fall-related injuries) because they were not sufficiently powered, their follow-up time was too short or because they had included subjects not at risk of falling.

The committee concluded that «Clear evidence demonstrates that participation in physical activity programs is safe and can effectively reduce falls in older adults at elevated risk of falls. Limited evidence indicates that physical activity programs reduce injurious falls in older adults. Currently, the evidence is strongest for physical activity interventions that include muscle strengthening and balance training activities in combination with

aerobic activities, especially walking. In addition, moderate, but inconsistent, evidence shows that Tai Chi exercise or balance-only training programs provide benefit» [2, part G, section 6, p. 16].

In a search of the literature data bases for more recent reviews, two Cochrane reviews could be identified [40,41].

The review of Gillespie et al. [40] compiled the evidence from 111 trials investigating interventions for preventing falls in older people living in the community; 43 of these trials tested the effects of exercise alone on fall risk. The review concluded that multi-component group exercise as well as individually prescribed multi-component home-based exercise reduces the risk of falling (risk reduction about 20%). Furthermore the review strengthens the evidence that Tai Chi exercise



reduces the risk of falling (risk reduction about one third).

The review of Howe et al. [41] did not investigate the effects of exercise on fall risk in older people but on balance as an outcome. 34 trials were included. Overall, significant improvements in balance ability were observed for exercise interventions compared to usual activity. Being aware of some methodological limitations in many of the reviewed studies the authors conclude that interventions involving gait, coordination and functional exercises, muscle strengthening, and exercise programmes with multiple components seem to have the greatest impact on balance. The longest follow-up time was one year, in most studies follow-up measures were assessed already at the end of the exercise programme. Thus, there

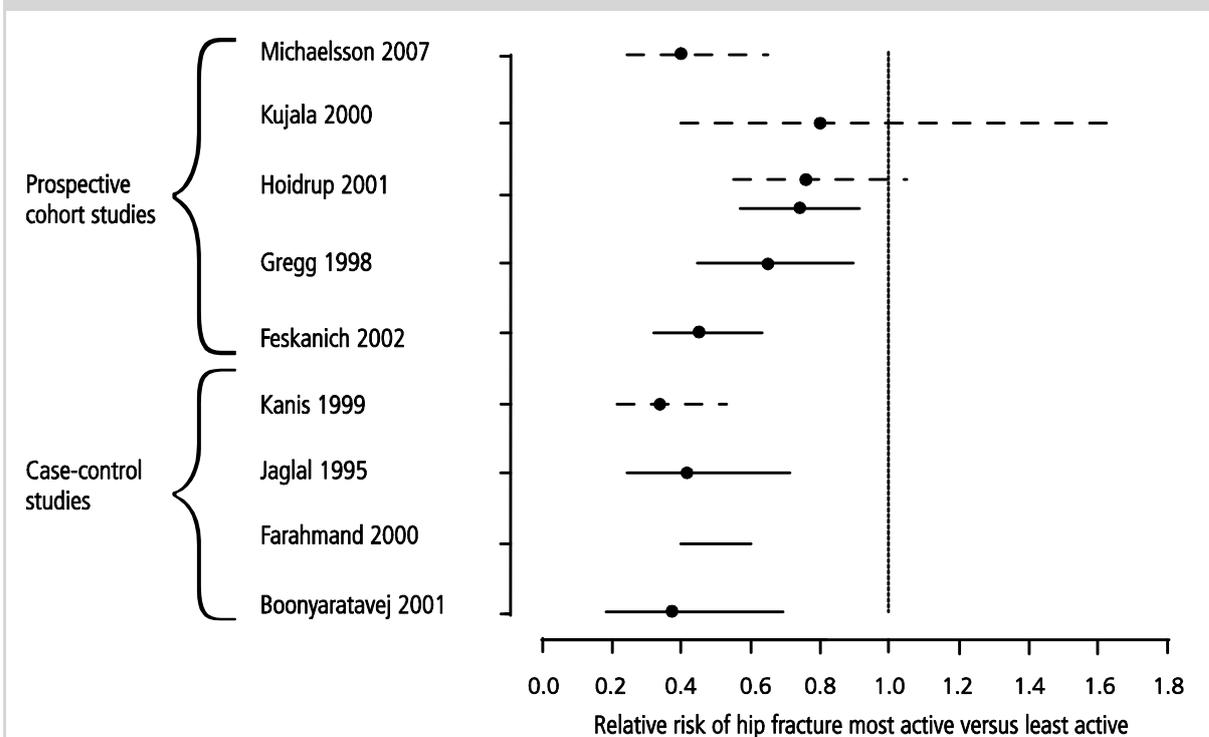
is very limited evidence so far that the observed effects are long-lasting. As a general comment it can be added, that the benefits of exercise programmes on fall risk cannot be expected to last very long after a programme has been terminated. Thus, continuous exercise activities will be required to protect individuals at risk from falling.

3.2 Risk of fractures in older adults

3.2.1 Overall assessment

The Physical Activity Guidelines Advisory Committee Report [2] could not identify a large randomised controlled trial RCT conducted to assess effects of physical activity on the incidence of fractures as an outcome. Only one small RCT demonstrating the positive effects of back-

Figure 10
Point estimates of relative risk (\pm 95% confidence intervals) of hip fracture from studies that examined multiple levels of physical activity [2, section G 1, p. 6]



Solid confidence intervals indicate studies of women; dashed confidence intervals indicate studies of men.

Figure courtesy of W. Kohrt

strengthening exercises on the protective effects for vertebral compression fractures was identified [42]. The committee states that a large RCT will be a major challenge because very large sample sizes and long follow-up times will be required. No RCT published after the report could be identified through the literature data bases.

Thus, the evidence compiled by the report [2] is based mainly on large cohort studies, but also a few case-control and cross-sectional studies were included (An overview of the results of cohort and case-control studies is given in figure 10, p. 61). In summary, the experts conclude that «(...) there is evidence for a beneficial association of physical activity with fracture risk. A limitation of these types of studies is that they do not isolate the role of physical activity as being causal in fracture reduction. However, the general consistency of favourable findings across multiple studies generates confidence that it plays a central role, if not a causal role, in the prevention of fractures». [2, part G, section 5, p. 5].

The evidence is particularly good for hip fractures. There also seems to be a dose-response-relationship, i. e. that greater volumes of activity (frequency, duration and/or intensity) are associated with greater risk reductions. Currently it doesn't seem possible to describe precisely the type or amount of physical activity necessary to effectively prevent fractures. Nevertheless, activity doses for example in the form of walking corresponding to those recommended for adults seem to be required [2].

A search of the literature data bases yielded another cohort study [43] published in 2008. Women of 70–75 years at baseline who had not

experienced a serious injury from falling recently were included in the study. After six years of follow up, individuals in the highest two of six physical activity levels had about half the risk of reporting a fracture in the past year compared to the least active women. The authors conclude that for primary prevention of fractured bones in women of this age group daily moderate to vigorous activity is necessary. These findings are in line with the conclusions of the Physical Activity Guidelines Advisory Committee Report [2] outlined above.

3.2.2 Effects of changes in physical activity in observational studies

The follow-up times in some cohort studies were long enough to allow not only the assessment of the association between physical activity at baseline and injury risk, but also the effects of changes of physical activity behaviour during follow up on the risk of subsequent fractures [44–47].

The largest study reporting associations between fracture risk and changes in leisure time physical activity is the Nurses' Health Study [44]. The study has followed the health status and life styles of US nurses for decades. Hip fractures accumulated during 12 years among more than 60,000 women between 40 and 77 years at baseline were analysed. Women who had increased their activity level within the six years preceding the 12 year follow-up period from low (less than 1 hour per week) to higher levels (at least four hours per week) had about half the hip fracture risk compared to those who had remained inactive. The analogous observation was reported for those who had become inactive before the follow up period: Their fracture risk had doubled compared to those who had remained active.

A cohort study in Sweden [46] followed more than 2,000 men (around 50 years of age at baseline) for up to 35 years. Changes in leisure time physical activity between baseline and the first follow up visit at age 60 were assessed. Incident fractures were derived from hospital discharge records. Compared to the men who were very active at both assessments, those who had changed from active to inactive had doubled their risk of having a hip fracture after the age of 60. Those individuals who were constantly inactive had a 2.3-fold risk of a hip fracture; while men who had increased their physical activity level in this time period had a risk that was only 50% higher compared to those who had always been active (Figure 11 displays the cumulative risk of a hip fracture in these four activity groups over after the age of 60.).

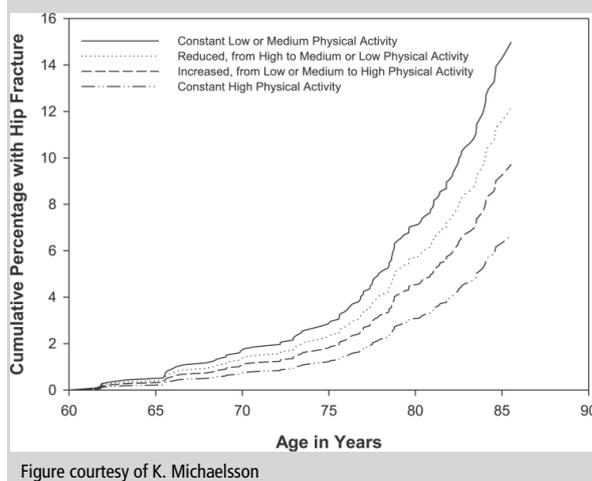
Another analysis used pooled data from three cohort studies in Denmark [45]. Similar findings were reported for men and women who decreased their leisure time activity levels substantially during follow up: their hip fracture risk had about doubled. This effect could still be observed when individuals with chronic disease before or during

follow up were excluded from the analyses. However, there was no evidence for a decrease of hip fracture risk upon an increase of leisure time physical activity levels.

In the fourth study finally, risk factors – among others declines in heavy outdoor work – on hip fracture risk in a population of 70+ were investigated [47]. Again, those who decreased their outdoor work had a more than two-fold hip fracture risk compared to those who had remained active (the only risk factor associated significantly with hip fracture risk in the multivariate model). The risk for soft-tissue injuries on the other hand remained unchanged after a decline in outdoor work. An increase of heavy outdoor work in a population of this age is rather unlikely; no respective data was presented. The sample size in this study was very small (n=284). It is thus possible that the study was underpowered to detect any significant associations between other risk factors that might have preceded the decline in outdoor work and fracture risk. Some of these factors could be associated with both the decline of activity and falls / hip fractures and be confounders (e. g. reduced visual acuity).

The evidence is thus consistent that decreases in physical activity levels are associated with an increase in hip fracture risk after a relatively short time. It is possible that chronic diseases occurring at this age are responsible for both the decline in physical activity and the increased risk of falls resulting in fractures. By excluding individuals with chronic diseases from the analysis, Hoidrup et al. accounted for this possible pathway [45]. On the other hand, the evidence for a decrease of hip fracture risk with increases of physical activity is somewhat less pronounced. Two studies found the

Figure 11
Survival curves of hip fractures after age 60 yrs by change in physical activity between 50 and 60 yrs of age. Survival curves are adjusted by reported changes in physical activity at age 70, 77, and 82 yrs [46]



expected negative association [44,46] a third one [45] found no relationship.

3.2.3 Risk of fall-related injuries in elderly people in population-based studies

The intervention studies on the risk of falls included in the Physical Activity Guidelines Advisory Committee Report [2] and the recent reviews presented above all describe trials with specifically recruited groups or individuals. There seems to be only a very limited number of studies assessing the effect of population-based interventions on the risk of falls or fall-related injuries. One Cochrane review from 2005 which was declared still up to date in 2007 [48] identified 35 population-based studies and included six prospective controlled community trials with older people in the analysis. Five studies used multi-component interventions, in three of them physical activity promotion was an element. The sixth study (from Taiwan) offered Tai Chi exercise for the entire population in the intervention villages. In all studies, there were decreases in the risk of fall-related injuries, however for some outcomes not statistically significant. The effects of the physical activity promotion elements cannot be isolated in these multi-component interventions. The authors concluded that «the review suggests that improvements (relative reduction of 6% to 33%) in the population-level injury indicators of fall-related injury can be achieved by the delivery of prevention programmes at the population level» [48].

3.3 Older adults: Evidence in brief

In older adults at increased risk there is good evidence that participation in physical activity programmes can reduce the risk of falls from any cause. The evidence is strongest for physical activity interventions that include muscle strengthening, balance training and aerobic activities, especially walking. In addition, there is growing evidence that Tai Chi exercises provide benefit.

There is moderate to good evidence that in older adults, higher levels of physical activity are associated with a reduced risk of osteoporotic fractures, in particular of the hip. There is some evidence that decreases in leisure time physical activity are associated with an increase of the hip fracture risk after a relatively short period of time. The evidence that self-selected increases in leisure time physical activity are associated with a decrease of the hip fracture risk is slightly less pronounced.

There is moderate evidence suggesting that also population-based fall-prevention programmes can reduce the risk of fall-related injuries from any cause.

4. Children and adolescents

Associations between levels of physical activity or specific behaviours and injury risks in children and adolescents are not discussed in the report of the Physical Activity Guidelines Advisory Committee [2]. Thus, this chapter is entirely based on a search of the literature data bases for reviews and single studies.

4.1 Activity related injury risks

4.1.1 Sport-specific injury rates in children and adolescents

It is important to notice that not only the type of activity, but also the age of the child, gender, and the context, such as institutionally organised versus self-organised sport, competition versus training, or the level of competition play an important role for injury risk [49]. A recent review [50] gives an overview of activity-specific injury rates in children and adolescents between 5 and 15 years of age from 48 studies. Both activities in an institutionally organised and self-organised context were included, but playground injuries and general school-time injuries were excluded. There were remarkable differences between sports, but also within sports and there can be an extreme variation of the injury rate for certain types of activities. For football, for example, the rate varied 1,000-fold, depending on the definition of injury, the age of the children or the context. Overall, most studies investigated team sports. There was very little information for children under the age of 8, as well as for sports in a self-organised context. In general, males seem to have a higher injury risk; however in some team sports (football, basketball) injuries seem to be more frequent among females [49].

For Switzerland, there is excellent data on acute sports injuries in adolescents [51]. At the beginning of the 1990-ies, the national «Youth + Sports» (Y+S) programme offered courses to 14–20 year old adolescents in around 30 sports. Each year, some 300,000 course participations were counted. The treatment costs of injuries attended by a physician that occurred during the courses were paid by the military insurance at that time. The study combined register data from the military insurance and from course protocols compiled by Y+S. Overall 0.46 injuries/1,000 hours of exposure were counted. Among boys and young men the most risky sports were ice hockey (0.86 injuries/1,000 hours), handball (0.72), football (0.66), wrestling (0.63) and hiking (0.36). Among girls and young women the respective sports were: handball (0.76), football (0.66) basketball (0.49), alpine skiing (0.39) and volleyball (0.38).

4.1.2 Common childhood activities and injury risk in the general population

There seem to be only very few studies investigating not only sports injuries in teams or other populations of athletes [49], but also all-cause injuries or activity-related injuries in the general population of children and adolescents.

The Childhood Injury Prevention Study (Australia) followed 4–12 year old children (N=744) prospectively for one year [52]. Parents filled in a 7-day diary on their child's physical activity and each activity had to be classified according to the ICECI codes [53]. During the one year follow up, each injury requiring first aid attention (serious injury: requiring professional treatment) was recorded. During one year, 504 injuries occurred in 315 children, 78% being directly related to physical

activity. 34% of all injuries required professional treatment, there was no difference for activity-related and other injuries in this respect. In the school-context, there was a higher injury risk for the older children of this cohort (10–12 year olds); however this was not the case outside school. Overall, 0.24 injuries/1,000 h occurred during institutionally organised and 0.16 injuries/1,000 h during self-organised activities outside school. When looking at specific activities [52], the highest risks were found for wheeled activities (inline skating, scooting, but excluding cycling) and tennis; however, these activities accounted for less than 5% of the total activity time; half the time in this cohort was spent in «active play». Table 12 gives an overview of the most frequent activities and those with the highest injury rates in this population.

Overall, boys had higher injury rates than girls, also if exposure was considered, both in an institutionally organised and a self-organised context. However, in some sports, such as football, injury rates among girls were higher (though not significant).

Another study concentrated on the risk of activity-related injuries in different contexts in a sample of 10–12 year olds in the Netherlands [54]. Some

1,000 children from 20 schools were followed for a school year (Control group of the intervention study described on p. 69, chap. IV.4.2.4). Participation in leisure time physical activity, sports and physical education in school was assessed with a written questionnaire at baseline and incident injuries were recorded during follow up. Injuries were defined as having to stop the current activity and/or not being able to go to school the following day and/or needing medical treatment. Overall, 0.48 injuries/1,000 h of activities were reported, with lowest rates for leisure-time physical activity (0.39/1,000 h), followed by physical education (0.5/1,000 h) and sports (0.66/1,000 h). 0.19 injuries/1,000 h of activity required medical treatment. Incidences of all injuries and of medically treated injuries alone were higher among girls than among boys due to more injuries during leisure time physical activity.

In summary, the studies investigating activity-related injury risks in children and adolescents in the general population [51,52,55] came up with comparable overall risks of activity-related injuries, even though definitions and assessment of exposures and outcomes varied. The overall risk in the youngest age group (5–12) was 0.17 injuries/1,000 h of activity for injuries outside school [52]

Table 12
Injury incidence of common childhood activities [52]

Activity	% of activity time spent	Injuries/1,000 h of activity*	Serious injuries/1,000 h of activity**
Active play	48.9%	0.50	0.18
Swimming	12.2%	0.19	0.10
Cycling	7.9%	1.00	0.11
Walking	5.3%	0.20	---
Outside chores	4.3%	0.12	---
Football	3.5%	1.03	0.41
Wheeled activity (e. g. inline skating; without cycling)	3.1%	1.72	0.41
Tennis	1.5%	1.19	0.48

*Injury requiring first aid attention

**Injury requiring professional treatment

and the values for the older age groups were higher: 0.46 injuries/1,000 h in the 14–20 year old Swiss Y+S participants [51], and 0.48 injuries/1,000 h in the 10–12 year old Dutch adolescents, respectively.

4.2 Physical activity as a risk factor or a protective factor for injuries

The main question of this report, whether in children and adolescents higher levels of physical activity are related to higher or lower rates of injury from all causes is not addressed in any of the studies identified for this report. However, there is a body of literature investigating protective or risk factors for different types of injuries. In some studies, specific measures of «physical activity» are conceptualised as risk factors for injuries, either decreasing or increasing the risk of injury under investigation.

4.2.1 Protective or risk factors for sports injuries

Most of the studies included in a review of the literature [49] investigated risk factors for sports injuries in children and adolescents in athletes of team sports such as football, ice hockey or basketball, and a few studies investigated other sports, such as for example gymnastics. This review compiled the evidence from 45 studies on factors associated with increased injury risk. «High speed sports» such as cycling or skiing had been excluded, because prevention strategies in these sports focus specifically on protective equipment.

Most of the risk factors identified were non-modifiable such as previous injury, an elevated competitive context of the sports activity or

increasing age. Male athletes were at greater risk for sports injuries; exceptions were higher risks for female athletes in some team sports such as football or basketball; the author suggests that causes could be lower skill levels of females in these sports or physiological characteristics.

Inadequate fitness such as poor endurance or not having done a pre-season training seemed to be a potentially modifiable factor associated with increased injury risk in some studies. On the other hand, in general no association was reported between strength or flexibility and injury rates [49].

4.2.2 Protective or risk factors for fractures

Fractures account for about a quarter of all injuries in adolescents [56]. Compared to younger children and middle age adults, fracture risk among pre-adolescents and adolescents is elevated with a peak between 10 and 14 years of age in girls and between 15 and 19 years in boys; the risk is comparable to the fracture risk in older adults under the age of 80 [57]. The mechanisms leading to a fractured bone in this age group are complex and there are a number of potential «physical activity factors» that could be associated with increased or reduced fracture risk. Low bone mineral density (BMD) is often named to be a risk factor for fractures, however, evidence for the association between fracture risk and BMD in children seems to be limited [58]. The isolation of independent effects of BMD or bone size and physical activity behaviour (the factors being interrelated) seems to be particularly challenging.

Results of a first case control study with 321 cases between 9 and 16 years of age in this research area were published in 2003/2004 [59,60]. After

adjustment for bone density, Ma et al. identified non-sports related physical activity as a protective factor for upper limb fractures and watching television (i. e. sitting behaviour) as a risk factor – even with a dose-response-relationship [59]. Lower scores in some coordination measures (lower manual dexterity, lower dynamic balance) were associated with increased fracture risk of the wrist and the forearm [60]. Among girls, sports participation was protective but among boys, sports participation was a risk factor for fractures of the upper limbs [59].

A first prospective cohort study assessing independent effects of bone mass and physical activity was published in 2008 [61]. Time being outdoors in the summer and in the winter, respectively, and time watching TV were assessed at age 5, the number of episodes with vigorous activity was assessed at age 9, bone mineral density was measured when children were 9 years old and fractures that had occurred within the past two years were collected at age 11. 2692 children had full data, 7.2% reported at least one fracture during follow up. Compared to boys, girls had a 23% lower fracture risk. Longer times outdoors in the summer at age 5 (≥ 28 h/week) doubled the risk of fractures between 9 and 11 years of age, while being in the middle tertile for being outdoors in the winter was protective. High levels of vigorous activities (7 or more weekly episodes compared to less than 4) doubled fracture risk. Watching TV was not associated with fracture risk. However, after stratification for BMD or bone size, frequent vigorous activity remained as the only independent risk factor.

Two overviews of the literature [57,62] name other factors that might be related to fracture risk such as obesity. Studies have suggested that obese

children have higher risks of fractures [63]. Possible mechanisms are a lower bone mineral density among obese children and adolescents and higher impacts when falling due to their high body weight [57]. Because obese children showed lower scores in balance test [64] it is suggested that this might be another cause for increased fracture risk among these children [62]. However, obesity as a risk factor for fractures was not confirmed by the cohort study mentioned above [61]. Lack of weight bearing exercise is mentioned as a potential risk factor in an overview, however, no studies are presented [62]. And inadequate outdoor activity to safeguard vitamin D status as potential risk factor for childhood fractures is mentioned as well, but it seems that no studies have been conducted so far to explore this mechanism [62].

Overall, it seems that frequent sports participation and/or vigorous exercise are associated with an increased fracture risk in boys. Fracture risk for girls is lower than for boys and the role of sports and vigorous exercise are not so clear. Little is known about effects of activities of moderate or light intensity; in one study, non-sports activities were protective [59] in the other study this relationship was not investigated [61]. The evidence on the role of sitting behaviour (TV watching) and obesity on fracture risk is conflicting.

4.2.3 Protective or risk factors for injuries in the school setting

There is a body of literature reporting on risk factors for injuries particularly in the school setting. Some authors conceptualise school injuries in children and adolescents in analogy to occupational injuries adults [65]. A systematic review of 18 cohort studies on injuries in school-aged children and adolescents found that male gender, psychological, behavioural and risk-taking behaviour problems were associated with increased injury risk [66]. Among the impressive list of factors associated with injury risk in this age group, only two physical activity related factors were reported in two studies: «poor gross motor control» among 7–11 year old girls as a risk factor for traffic accidents [67] and «participation in 1–3 team sports» in 12–14 year old adolescents as a risk factor for all-cause injuries [68]. A prospective study not included in that review [69] found that in 8–12 year old children – in contrary to the authors' hypothesis – higher balance and agility scores were associated with increased injury risk. They speculate that children with better motor skills might tend to take more risks than their counterparts with less motor abilities.

4.2.4 Interventions in the school setting to prevent injuries

A report published in German gives an overview of the potential of improving motor skills in young children for the reduction of injuries [70]. It concludes that children with low motor skills do not necessarily have more injuries, because they are less active and thus less exposed than children with good motor skills; and that – vice versa – injured children do not have more deficits in their

motor development. The report also concludes that improving motor skills, in particular by reducing the deficits among those with the lowest skills, can reduce injuries. This second conclusion is based on six reports published in German and on one publication in a scientific journal, also in the German language [71]. In this study, after a seven-month intervention to improve motor skills among 4 to 6 year old children the number of accidents recorded by the kindergarten teacher fell from 9 to 2 per month in the intervention group (n=71) while the respective figures were 8 and 9 in the control group (n=75).

In the Netherlands [72], the effectiveness of an 8-month intervention to reduce injuries related to physical activity in sports clubs, during physical education or leisure time among 10–12 year olds was assessed in a clustered randomised controlled trial including 40 schools (2,210 students participating). Apart from elements for awareness raising such as posters or newsletters and an interactive website, the intervention also included five minutes of specific exercises to improve strength, speed, flexibility, and overall coordination before and after each lesson of physical education. Overall, the rate of total activity-related injuries was lower in the intervention than in control group (though not significantly); and the intervention was particularly effective among students with low levels of physical activity. However, it is not known how much of this reduction of injury rates is attributable to the exercise component of the intervention.

Overall, the number of studies with rigorous design in the international literature is still limited. There are some first indications that specific exercises to improve fitness components have the potential to

reduce activity-related injury rates among school children, in particular among those with low levels of physical activity. Nevertheless, it seems too early to state that there is evidence for the hypothesis that improving motor skills in young children reduces injury rates in the school context or overall.

4.2.5 Health behaviour – risk behaviour

Among adolescents, health behaviour is of particular concern. As described above for injuries in the school setting, some studies conceptualise «physical activity» – usually sports participation – as one of a variety of behavioural factors that can be associated with injury risk.

In secondary analyses of the WHO survey Health Behaviour in School-aged Children (HBSC-survey) the associations between health behaviour and injury rates have been investigated for 11–19 year olds in Switzerland [73], 11–15 year olds in Canada [74] and in an international comparison [75]. Furthermore, a Finnish study with 12–18 year old adolescents used similar instruments [56]. Injuries requiring medical attention as well as physical activity were assessed retrospectively. In the Swiss analysis, the weekly duration of sports participation was found to be an independent risk factor for sports injuries, as well as participation in risky sports and increasing pubertal age. Data on injury not related to sports were collected, however not included in this analysis [73]. The Canadian analysis [74], on the other hand, chose injuries not related to sports as an outcome and lack of exercise as well as participation in sports as predictors: Injury risk from other causes than sport was not associated with these two physical activity indicators. The most complete results are provided by the Finnish study [56]: Daily sweating in

connection with exercise in a sports club increased overall injury more than threefold compared to not attending a sports club. When taking into account also intermediate activity groups the risk seemed to increase linearly. The frequency of physical activity outside sports clubs, however, was not significantly associated with injury rates.

The weekly duration of exercise outside school was not associated with overall injury risk at age 12–13 in a US study, while engagement in team sport was associated with an increased injury risk at age 13–14 in the same study population [68]. And in a British survey on students' health and lifestyles, doing team sports was identified as risk factor for injuries from all causes, along with young age (18–19, compared to 20+); other forms of physical activity were not investigated [76].

The international comparison of the WHO-HBSC surveys investigated the association between injury risk and the number of risk behaviours such as smoking, not using a seat belt, bullying etc. Even though sports participation has been identified as a risk factor for injuries in some studies, this factor was not included in the report. Injury risk seemed to increase linearly with the number of risk behaviours. This gradient could be observed for sports- and non-sports injuries [75]. Another study (with a prospective design) investigated multiple risk factors for injuries in the school setting. It was distinguished between sports- or activity-related injuries and injuries from other causes but physical activity or sports behaviour was not included as exposure [77].

4.3 Overall – what is known?

The literature on the relation between physical activity and injury risk in children and adolescents seems to have a predominantly pathogenetic perspective. Measures of physical activity that could protect from injuries are mentioned in a few papers but are usually not investigated. Furthermore, if no associations between a measure of physical activity as exposure and injury are found (i. e. the investigated exposure is not a risk factor for injury) these findings are «hidden in a subordinate clause»; and finally, such predictors are not included in overall models. Measures of physical activity other than participation in sports or vigorous activity would be available in some studies, and injuries from other causes than sports as well – however, with a few exceptions, such associations were not investigated.

Overall, virtually nothing is known about the relation between physical activity and injuries in children younger than about eight years of age. This cannot be surprising because measurement of physical activity in young children is difficult and methods have been developed only recently. Therefore, also studies investigating associations between levels of activity and injury are still lacking. Some data on preadolescents is available and the majority of studies focus on adolescents.

Boys have more injuries than girls. However, if exposure to physical activity is considered girls may have higher injury incidences in some contexts or for some sports.

Starting in preadolescence, injury rates increase until about the age of about 15 years. Different causes for this observation have been named: Body

mass increases resulting in higher forces exerted on the body when jumping, pivoting, colliding; participation in sports may become more aggressive with hormonal changes; during the adolescence growth spurt bones grow fast resulting in temporarily lower bone quality; and because of changing body proportions adolescents may become «clumsy» and injuries may be attributed to neuro-physiological reasons.

Among all age groups, injury rates are highest in adolescents, with mainly sports injuries contributing to the total number of injuries. It is therefore not surprising that participation in sports or vigorous activity is strongly associated with an increased risk of sports-related injuries. There is some evidence for a dose-response-relationship in this respect. Furthermore, participation in sports or vigorous activity seems to be associated with an increased risk of injuries from all causes and fractures from all causes. Given the high percentage of all injuries or fractures that must be attributed to sports activities, this overall association is plausible – even though the relationships between activity levels and injuries from other causes than sports are not yet clear.

With very few exceptions, associations between levels of total physical activity, levels of moderate intensity activity or participation in non-sports activities, respectively, and injury or fracture rates have not been investigated. There is some first suggestion that levels of non-sports activities are not related to overall injury risk and that light activities could be protective regarding fractures.

After all, engaging in risk behaviours is a characteristic of adolescence – with participation in vigorous sports being just one among numerous

behaviours that can increase injury risk in this age group. Thus, measures such as protective equipment, specific preparatory training or adequate rules are important for injury prevention in youth.

4.4 Children and adolescents: Evidence in brief

Starting in preadolescence, injury risk increases until about 15 years of age. Boys have more injuries than girls; however, if exposure to physical activity is considered this gender difference becomes less clear.

There is consistent evidence that participation in sports or vigorous activity is strongly associated with an increased risk of sports-related injuries, and there is some evidence for a dose-response-relationship in this respect.

There is some evidence that participation in sports or vigorous activity seems to be associated with an increased risk of fractures and injuries from all causes.

There is limited evidence from few studies suggesting that non-sports activities are not associated with injuries from all causes and that non-vigorous activities could be protective of fractures.

5. Specific populations

5.1 Athletes

Injuries among athletes are common and previous injury is a strong predictor of injury incidence among young [49] and adult [78–80] competitive

athletes as well as among recreational athletes of the general population [25,80]. Interventions to reduce injury risk in athletes, both for primary prevention and for those with a history of previous injury are thus very important. In general these intervention studies are very specific regarding the type of intervention, the sports discipline, age and sex, level of competition and type of injury to be reduced. In handball, for example, a structured warm up programme to improve running and landing technique as well as neuromuscular control, balance and strength reduced the risk of knee and ankle injuries by almost 50% in adolescent primarily female athletes in Norway [81]. And a neuromuscular training among female athletes of the three Norwegian top divisions reduced the risk of anterior cruciate ligament injuries overall by about one third after two seasons, with the highest effects among players of the elite division completing the programme [82].

There are some systematic reviews on the effects of specific intervention components to prevent injuries such as warming up [83] or doing stretching exercises [84]. Other reviews focus on the prevention of specific injuries, such as the Cochrane reviews on interventions for preventing ankle ligament injuries [85] and on lower limb soft-tissue injuries in runners [86].

These studies and reviews provide and describe the evidence for different sport disciplines, for different target groups, for different interventions as well as sometimes also for different injury outcomes. However, it is beyond the scope of this report to provide a complete overview and to comment on them specifically.

5.2 Military trainees

Studies with army trainees can serve as a model to illustrate different aspects of the relationship between physical activity and the risk of injury because both levels of physical activity and overall injury risk are high. A specific value of these studies is that during army training, young healthy men and women of the general population with different levels of physical activity or fitness at baseline have to perform at comparable levels. Thus, individual increases in activity during army training can differ substantially. Recruits undergo several months of aerobic and muscular training such as marching, running or general conditioning exercise. The dose of activity usually performed [87] can be six times more than the minimum recommended to the general population.

Levels of musculoskeletal injuries are high with the onset of primarily overuse injuries corresponding to the dose of the «prescribed» activity [88]. Levels of injuries tend to be higher among females than among males, but females are often also less fit at the beginning of their training [89]. After adjustment for initial levels of fitness, injury risk among men and women has been shown to be comparable [89]. Several studies have indeed demonstrated that high levels of fitness were associated with lower injury risk during intensive training [87,90,91].

Interventions providing a formal pre-course conditioning programme for recruits with low levels of fitness demonstrated in one study that injury incidence during the subsequent regular training was lower among those who had been assigned to the programme in comparison to those who had entered the base training directly [92] and

that they had lower attrition rates and tended to have lower injury risk in another study [93].

Overall, studies with army trainees have demonstrated that among young and healthy individuals who need to perform at high levels, injuries are more frequent among those with low fitness, and that injury incidence can be reduced by specific conditioning programmes. While many of these studies have looked at all injuries, some have also shown these relationships specifically for traumatic injuries [94].

5.3 Overall – what is known?

As already shown for fall prevention in elderly people (chapter IV.3, p. 59), there is evidence that specific training programmes can reduce the risk of injury among individuals who need to perform near or at the limits of their capacities. This is the case among athletes in sports, as well as among army trainees, among the latter particularly in those entering the training programmes with limited capacities. In all these cases, targeted interventions seem to be most effective. It is not yet clear to what extent these findings can be generalised to larger population groups.

5.4 Specific populations: Evidence in brief

Specific training interventions have been shown to be effective in reducing sport injuries in athletes. The strength of the evidence for effectiveness depends on the sport discipline, the target group, the elements of the intervention and the injury outcome of interest.

Army training is characterised by high levels of physical activity, by high injury risks and by some-

times considerable differences in previous activity and fitness levels. There is consistent evidence that injuries are more frequent among trainees with low fitness. A number of studies have shown that injury incidence can be reduced by specific conditioning programmes.

It is not yet clear to what extent these findings can be generalised to larger population groups.

6. Integration of the current state of knowledge into national and international guidelines and recommendations

Two international research institutions with expertise in the field of physical activity promotion and injury prevention were invited to comment on a draft of this report: The EMGO Institute of the Free University of Amsterdam, Netherlands and the CDC in Atlanta, USA. Experts were asked whether their institution or their country had a policy or specific recommendations regarding the relationship between physical activity promotion and injury prevention. And if this was not case, whether the experts agreed with our interpretation of the evidence expressed in the recommendations for implementation and the recommendations for research.

In the Netherlands, there is no policy regarding the relationship between physical activity promotion and injury prevention. It seems that currently the topic is not a priority on the political agenda. There have been attempts to get support for investigating the link between physical activity promotion and injury prevention and quantifying the burden of a physically active lifestyle which were not successful so far. Overall, the experts

agree with the conclusions and recommendations in this report.

In the US, the current physical activity guidelines (www.health.gov/paguidelines/guidelines/default.aspx#toc) include specific recommendations for safe physical activity. To do physical activity safely and reduce the risk of injuries, people should:

- Understand the risks and yet be confident that physical activity is safe for almost everyone.
- Choose to do types of physical activity that are appropriate for their current fitness level and health goals, because some activities are safer than others.
- Increase physical activity gradually over time whenever more activity is necessary to meet guidelines or health goals. Inactive people should «start low and go slow» by gradually increasing how often and how long activities are done.
- Protect themselves by using appropriate gear and sports equipment, looking for safe environments, following rules and policies, and making sensible choices about when, where, and how to be active.

V. Discussion and conclusion

1. Where we are now

1.1 Main findings

This report presents an overview of the literature on the association between physical activity and injury risk for different age groups. The aim was to analyse the literature with a salutogenetic perspective focussing on the question whether physically active individuals have less injuries from any cause than their inactive counterparts, or going even further, whether promoting physical activity can at the same time prevent injuries. The key findings according to the three guiding questions are presented below.

- a) What are the associations between habitual physical activity behaviour as well as changes in physical activity and the risk of injuries in different age groups of the general population?

The strongest evidence for this overall question is available for older adults. For individuals at increased risk in this age group there is good evidence that participation in multi-faceted physical activity programmes including strength and balance training as well as aerobic activities can reduce the risk of falls from any cause. Furthermore, there is moderate evidence suggesting that also population-based fall-prevention programmes including physical activity components can be effective. Regarding osteoporotic fractures, there is moderate to good evidence that higher levels of physical activity are associated with a reduced risk of fractures, in particular of the hip.

For adults of the general population at working age, there is some consistent evidence that higher levels of physical activity, in particular regarding intensity, are related to higher numbers of activity-related injuries. The injury risk from moderate intensity activities seems to be low. There are some suggestions that activity-related injuries could be more severe among those who are not active on a regular basis. There are indications from some studies suggesting that higher levels of physical activity are not necessarily related to increased risks of all-cause injuries.

Participation in sports or vigorous activity is strongly associated with an increased risk of sports-related injuries and related to injuries from any cause. In children and adolescents there is very limited evidence from few studies suggesting that non-sports activities are not associated with injuries from all causes and that non-vigorous activities could be protective of fractures.

In summary, physical activity behaviour, injury rates and injury risk change over the life course. The US Physical Activity Guidelines Advisory Committee concludes that «(...) for a specific dose of activity older people are more likely than younger people to be injured. In practice, however, older people consciously or unconsciously appear to moderate their physical activity so that they become injured less frequently than do younger persons. When compared to inactive individuals, physically active younger persons are injured more frequently than inactive younger persons whereas physically active older persons are injured less frequently than

inactive older persons.» [2, section G 10, p. 29]. In addition to the general behavioural differences between age groups, also age-specific preferences for sport disciplines or forms of physical activity could contribute to an explanation for these observations. While the differences in the direction of the relationship between physical activity and injury risk between older and younger people are clear, the age corresponding to the change of the direction has not yet been identified.

b) What are the effects of training programmes on the risk of injuries in specific population groups?

There is good evidence that training programmes can reduce the risk of falls in elderly people, particularly those at risk for falls. The evidence is strongest for physical activity interventions that include muscle strengthening, balance training and aerobic activities, especially walking. In addition, there is growing evidence that Tai Chi exercises provide benefit. There is also evidence for the effectiveness of training programmes in reducing sport injuries in athletes, in strength differing according to the sport discipline, the target group, to the elements of the intervention as well as to the injury outcome. A number of studies have shown that injury incidence in military trainees can be reduced by specific conditioning programmes.

It is plausible that physical activity promotion and training programmes in children could improve overall fitness and specifically motor skills and thereby reduce accident risks. However, further mechanisms such as risk seeking or avoidance might be involved. So far, the scientific publications available on this topic do not provide the evidence necessary for a specific statement.

Together with the evidence for associations with physical activity behaviour presented above, it can be concluded that physical activity and sport promotion in younger people particularly need specific elements for injury risk control. In older age groups physical activity promotion as such becomes injury prevention. Again it is not yet clear, at which age and under which circumstances the «change of the direction» takes place also for interventions. And it is not yet clear whether these findings can be generalised to larger population groups.

c) How is the current state of knowledge regarding physical activity promotion and injury prevention be integrated into national and international guidelines and recommendations?

Experts in the field of physical activity promotion and injury prevention from the EMGO Institute of the Free University of Amsterdam (Netherlands) and the CDC in Atlanta (USA) provided information about the situation in their country and commented on the report. In the US, specific recommendations for safe physical activity have been included in the national physical activity guidelines issued in 2008. The recommendations formulated in this report are in line with the US guidelines. The Netherlands don't have specific policies, however, the experts agree with the recommendations of the report.

1.2 Synthesis

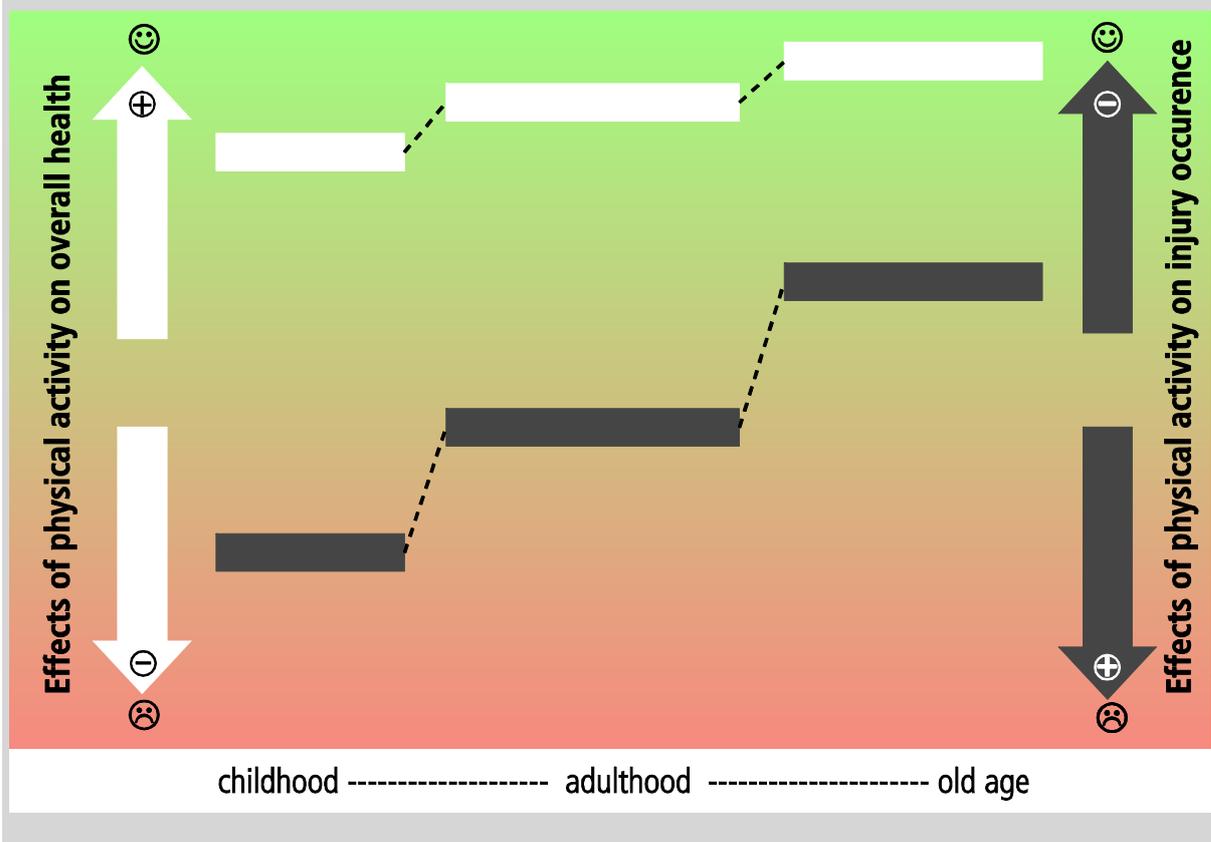
Figure 12 attempts to give a synthesis of the evidence on the association between physical activity and overall health over the life course on the one hand and the possible relation between physical activity and the risk of injuries from childhood to old age on the other hand. There is strong evidence that physical activity is good for health in all age groups. For methodological reasons and because of the mechanisms related to the development of chronic diseases, health effects in adults are still better documented than in children. Older adults benefit most immediately from regular physical activity. Promoting physical activity in older adults also reduces the risk of injuries. In adults at working age, higher levels of activity seem to be related to higher numbers of activity-related injuries but not

necessarily to more injuries from all causes. In children and adolescents, engagement in sports or vigorous activities is associated with higher levels of injuries from any cause. Summing up, there is some evidence for the direction of the association between physical activity behaviour and injury risk in different age groups, however, the strength of these associations and also the age periods at which the associations change in magnitude and direction are still to be explored.

1.3 Methodological issues

The reviews and studies identified for this report provide some insights into the complex relation between physical activity promotion and injury prevention in the general population. Nevertheless, this research area still seems to be in its infancy.

Figure 12
Synthesis of the association between physical activity behaviour and health and the possible relation between physical activity behaviour and injury risk over the life course



As mentioned above, apart from studies in older adults, there are only very few papers investigating the relation between physical activity promotion and injury prevention from a salutogenetic perspective. The majority of studies aim at identifying risk factors for injuries. Consequently, physical activity related behavioural factors that could prevent injuries are rarely investigated and if no associations are found – i. e. the behaviour is not a risk for injury – it is likely that these findings are not reported.

The indicators and methods to assess both physical activity behaviour as the exposure and injuries or accidents as outcomes are not standardised, making it difficult to compare studies (Table 9 and Table 10, p. 51). There are efforts to develop valid and feasible instruments to assess physical activity behaviour in population studies and to standardise methods on the international level [8]; nevertheless, assessing exposure remains a challenge in this research area. Regarding injury outcomes, the variety of indicators and their assessment is remarkable as well and the need for standardisation of methods has been recognised. The number of studies with a prospective design is limited and cross-sectional studies assessing the occurrence of injuries retrospectively have some important methodological limitations. Firstly, recall seems to depend on the time since the injury occurred: It has been demonstrated that injury incidence decreased gradually with increasing duration between assessment and the point in time when injury had occurred. It was thus recommended that in surveys with children and adolescents recall periods should not be longer than one to three months [95]. Furthermore with a retrospective assessment of injury rates it can not be excluded that an injury affected the physical

activity habits of an individual and that therefore the causal pathway of the association between physical activity and injury is reversed. It is thus strongly recommended that future studies in this area should use prospective designs.

2. Where to go from here

2.1 Recommendations for implementation

Despite its limitations, the current state of evidence allows the following specific recommendations for implementation and practice:

- **Children and young people: Link up physical activity promotion and accident prevention**

The promotion of physical activity and sport in children is an important public health issue. The behaviour of small children is very much influenced by their parents' attitudes and choices. Measures for safety and accident prevention can support these parents in making choices for their children's activities. To avoid an increase in injuries in young people, it is particularly important to accompany physical activity promotion with all measures of accident prevention in this age group.

- **Adults: Support the right choices in physical activity promotion**

Adults should be encouraged to maintain and increase their sport and physical activity behaviour. They should be supported in taking up activities appropriate for this age group. If previously inactive or sporadically active individuals are addressed, activities that have low injury risks such as hiking, walking, cycling or swimming should be recommended. For those who plan to start with vigorous activities

such as endurance training, it is important to start gradually. And finally, people who are already very active should carefully plan their training sessions, competitions and recovery phases in order to minimise the risk of traumatic or overuse injury.

– **Elderly people: Physical activity promotion is accident prevention**

Maintaining and increasing physical activity in elderly people helps to keep them independent and reduce falls and fractures. Multidimensional training programmes seem to be most effective, and the general measures of accident prevention should be observed.

2.2 Recommendations for research

The Report of the Physical Activity Advisory Committee [2] has identified a number of research needs regarding physical activity and adverse events: The first topic for further research in the section on adverse events of the report addresses the question whether active and inactive individuals are at equal risk for injuries from any cause. It is noted that «the severity of injury and the type of activity are likely to be important determinants of the relationship» [2, part G, section 10, p. 41]. Further research needs to concentrate on what the appropriate starting doses of activity and the sizes of increase are in order to prevent activity-related injuries among those who become more active. More detailed analyses should contain information on the severity of injuries and their consequences for quality of life and economics. Incidence and risk factors for injuries in association with walking as a very common form of physical activity are of specific interest. In the prevention of falls among older adults, it is not yet clear which programmes

are most suitable for which group and whether there is a threshold or dose-response effect of physical activity in this respect. Furthermore, a sufficiently powered randomised controlled trial is still needed to assess the effects of physical activity on fractures as an endpoint.

There are challenges that both physical activity promotion and injury prevention have in common: Who is reached by an intervention and how can those be reached that are most in need? With respect to specific questions on the relation between physical activity promotion and injury prevention it seems most important to further quantify the relationship between physical activity and injury risk as well as the effects of interventions, to investigate the specificities and differences between age groups, and to verify the generalisability of experiences from specific groups such as athletes or military trainees to the general population. The following specific recommendations can be derived:

– **Make most of existing datasets and improve the methods**

There are indications that a number of surveys and studies have assessed information on exposure and outcomes but that these associations have not been investigated or published. Secondary analyses of these existing datasets can provide additional evidence. Progress in the assessment methods for both physical activity behaviour and injury occurrence will lead to new insights.

– **Conduct population studies with prospective designs**

Population studies among children and adults with prospective designs and adequate methodology are rare. They will allow addressing the most urgent questions as listed above.

– **Assess the effect of physical activity promotion interventions on injury risk**

There are some physical activity promotion interventions targeting adults that have a high potential for both effectiveness and large scale implementation, such as community interventions and physical activity promotion through primary care or at the work site. Their effects on injury risks should be assessed and so a comprehensive view of the overall positive and negative effects of an intervention will be possible. Furthermore, the question whether interventions to improve general fitness and in particular coordination or motor skills in young children to reduce the number of injuries should be addressed with well designed intervention studies.

2.3 Concluding remarks

A number of important research questions are still unanswered concerning the relationship between physical activity and injury risk. However, there are strong indications already that physical activity promotion and accident prevention are allies and not opponents. The optimal effect on public health and the optimal use of resources will be attained by adhering to the practice recommendations outlined above. The research recommendations will allow to strengthen the body of evidence and to contribute to further progress in the practice of physical activity promotion and accident prevention.

Glossary

Sources

- CDC Glossary of physical activity terms:
<http://www.cdc.gov/physicalactivity/everyone/glossary/index.html>
- CDC Glossary of epidemiology terms: <http://www.cdc.gov/excite/library/glossary.htm>
- Society for Advancement of Violence and Injury Research: <http://www.injured.org/docs/Glossary.pdf>
- online dictionaries: <http://www.answers.com/topic/>
- specific references as listed

Terms

Accident (bfu, based on definition in the law): A sudden unintentional impact of an unexpected external factor on the human body, affecting a person's physical, mental or psychological health or resulting in death.

Accident (Insurance dictionary): Unexpected, unforeseen event not under the control of the insured and resulting in a loss. The insured cannot purposefully cause the loss to happen; the loss must be due to pure chance according to the odds of the laws of probability. There seems to be a consensus among many specialists in injury prevention in the English speaking world that the term 'accident' should not be used. «The reasoning is that the common meaning attached to the word 'accident' is a random or chance event, and thus cannot be prevented». The term 'accident' may be appropriate «to describe the primary event in a sequence that leads ultimately to injury if that event is genuinely not predictable».(Pless & Hagel, 2005).

Aerobic physical activity: Activity in which the body's large muscles move in a rhythmic manner for a sustained period of time. Aerobic activity, also called endurance activity, improves cardio-respiratory fitness. Examples include walking, running, and swimming, and bicycling.

Balance: A performance-related component of physical fitness that involves the maintenance of the body's equilibrium while stationary or moving.

Balance training: Static and dynamic exercises that are designed to improve individuals' ability to withstand challenges from postural sway or destabilizing stimuli caused by self-motion, the environment, or other objects.

Bone-strengthening activity: Physical activity primarily designed to increase the strength of specific sites in bones that make up the skeletal system. Bone strengthening activities produce an impact or tension force on the bones that promotes bone growth and strength. Running, jumping rope, and lifting weights are examples of bone-strengthening activities.

Exercise: A subcategory of physical activity that is planned, structured, repetitive, and purposive in the sense that the improvement or maintenance of one or more components of physical fitness is the objective. «Exercise» and «exercise training» frequently are used interchangeably and generally refer to physical activity performed during leisure time with the primary purpose of improving or maintaining physical fitness, physical performance, or health.

Exposure: Coming into contact with a cause of, or possessing a characteristic that is a determinant of, a particular health problem.

Flexibility: A health- and performance-related component of physical fitness that is the range of motion possible at a joint. Flexibility is specific to each joint and depends on a number of specific variables, including but not limited to the tightness of specific ligaments and tendons. Flexibility exercises enhance the ability of a joint to move through its full range of motion.

Health-enhancing physical activity: Activity that, when added to baseline activity, produces health benefits. Brisk walking, jumping rope, dancing, playing tennis or soccer, lifting weights, climbing on playground equipment at recess, and doing yoga are all examples of health-enhancing physical activity.

Incidence: A rate that measures the frequency with which a health problem, for example a new injury, occurs in a population. In calculating incidence, the numerator is the number of new cases occurring in the population during a given period of time, and the denominator is the total population at risk during that time.

Injury: A bodily lesion at the organic level, resulting from acute exposure to energy (this energy can be mechanical, thermal, electrical, chemical or radiant) in an amount that exceeds the threshold of physiological tolerance. In some cases (e.g. drowning, strangulation, freezing), the injury results from an insufficiency of a vital element (Baker, O'Neil, Ginsburg, & Li, 1992).

Injury prevention: refers to the actions or interventions that prevent an injury event or violent act from happening by rendering it impossible or less likely to occur (World Health Organization WHO, 2006).

Injury rate: A statistical measure describing the number of injuries expected to occur in a defined number of people (usually 100,000) within a defined time period (usually 1 year).

Injury risk: The probability that any given individual in a group of individuals will get injured. A proportion or probability is a number between 0 and 1, but is often multiplied by 100 and referred as (percent) chance of injury (Hopkins, 2010).

Intentional Injury: Injuries that result from purposeful human action whether directed at oneself (self-directed) or others (assaultive), sometimes referred to as violent injuries.

Intensity: Intensity refers to how much work is being performed or the magnitude of the effort required to perform an activity or exercise.

Intervention: An action or program that aims to bring about identifiable outcomes.

Lifestyle activities: This term is frequently used to encompass activities that a person carries out in the course of daily life and that can contribute to sizeable energy expenditure. Examples include taking the stairs instead of using the elevator, walking to do errands instead of driving, getting off a bus one stop early, or parking farther away than usual to walk to a destination.

Moderate-intensity physical activity: On an absolute scale, physical activity that is done at 3.0 to 5.9 times the intensity of rest. On a scale relative to an individual's personal capacity, moderate-intensity physical activity is usually a 5 or 6 on a scale of 0 to 10.

Overuse injury: An injury caused by overexerting the body with excessive workloads at a normal frequency of movement, with normal workloads at an increased frequency of movement, or with low workloads at an excessively rapid frequency of movement. Overuse injuries often occur at the microscopic level and are caused by repeated microtrauma.

Outcome(s): Any or all of the possible results that may stem from exposure to a causal factor or from preventive or therapeutic interventions; all identified changes in health status that result from the handling of a health problem.

Physical activity: Any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level. In these Guidelines, physical activity generally refers to the subset of physical activity that enhances health.

Physical fitness: The ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and respond to emergencies. Physical fitness includes a number of components consisting of cardio-respiratory endurance (aerobic power), skeletal muscle endurance, skeletal muscle strength, skeletal muscle power, flexibility, balance, speed of movement, reaction time, and body composition.

Relative risk: A comparison of the risk of a health problem in two groups.

Safety promotion is the process to develop and maintain the basic conditions for safety at a local, national and international level by individuals, communities, governments and others, including businesses and non-governmental organisations (Maurice et al., 2001).

Strength: A health and performance component of physical fitness that is the ability of a muscle or muscle group to exert force.

Study, observational: An epidemiologic study in which there is no intervention and nature is allowed to take its course. Changes or differences in one characteristic are studied in relation to changes or differences in others.

Study, case-control: An analytic study that compares a group of people with a certain disease, chronic condition, or type of injury (case-patients) with a group of people without the health problem (controls) to detect differences in characteristics such as exposure to an agent.

Study, cohort: (Syn: follow-up, longitudinal, and prospective study) An observational analytic study in which enrollment is based on status of exposure to a certain factor or membership in a certain group. Populations are followed and disease, death, or other health-related outcomes are determined and compared.

Traumatic injury (Insurance dictionary): Bodily or emotional injury resulting from physical or mental wound or shock. A traumatic injury is caused by something outside the person's body as opposed to a sickness or a disease. An example would be injury to a hand that is smashed in a machine, or a nervous breakdown caused by stress on the job.

Trial, community: An experimental study that uses data from communities. Investigators identify the type of exposure that each community has had and then follow the communities' health status to determine the effects of the exposure.

Trial, randomized clinical (syn: controlled): A clinical trial in which individuals are randomly assigned to exposure or treatment groups.

Unintentional Injury: An injury that is judged to have occurred without anyone intending harm be done; in many settings these are termed «accidental injuries».

Vigorous-intensity physical activity: On an absolute scale, physical activity that is done at 6.0 or more times the intensity of rest. On a scale relative to an individual's personal capacity, vigorous-intensity physical activity is usually a 7 or 8 on a scale of 0 to 10.

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