

Acculturation and physical activity among immigrants: a systematic review

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Abstract

Aim The acculturation process presents numerous challenges that could benefit or adversely affect immigrants' health practices. The goal of this review was to present a systematic summary of studies examining the relationship between acculturation and physical activity among immigrants and ethnic minority populations.

Subjects and methods Systematic review based on 44 original studies found in electronic databases (Psychinfo/Psyndex, Eric, Pubmed/Medline, Web of Science, Sport-Discus). Studies were eligible if they were written in English, German or French, incorporated a measure of acculturation and physical activity, exercise, or sport as independent and dependent variables, and provided statistical information to judge the level of significance. The 44 studies found included 760,242 participants. A narrative synthesis was performed. Causality of effects was examined based on seven criteria: consistency, strength of associations, specificity of effects, temporality, gradient, plausibility and experimental evidence.

Results Acculturation was associated with higher leisure time physical activity in 57% of all studies (even after controlling for potential confounds), independent of participants' gender, age and ethnic background. The main limitations of this review are that findings were not weighted for sample size and that publication biases might have contributed to an overestimation of the relationships.

Conclusion Prevention programs aimed at stimulating participation in physical activity among immigrants should give priority to individuals with low acculturation levels and it

should consider culturally specific beliefs and constraints. Additionally, prevention programs could make an effort to promote acculturation among immigrants. Future studies should use longitudinal designs which include objective assessments of physical activity and which use multidimensional and bidirectional definitions of acculturation.

Keywords Ethnicity · Exercise · Immigrants · Immigration · Minority · Sport

Introduction

Reducing health disparities in ethnic populations is a major public health objective in many Western nations (Carvajal et al. 2002). Having a migration background or ethnic minority status, however, does not constitute a health risk per se. Sam (2006) presented several hypotheses of how migration might be related to health. First, health differences might be due to a selection effect. That is, individuals who are predisposed to health problems are those who want to emigrate (e.g. coming from poor countries, traumatic experiences). Second, the stress effect postulates that health differences might be due to the inability of immigrants to cope with the stresses associated with migration and the acculturation thereafter. Third, the healthy immigrant effect assumes that people who migrate are healthier than those who do not. And fourth, the immigrant paradox suggests that immigrants have better health than their socio-economic background suggest, and that, while they arrive with better health than their non-immigrant counterparts, this better health deteriorates over time (e.g. with prolonged length of residence or increasing generational status). Interestingly, empirical support exists for all four hypotheses, which might be due to the fact that the circumstances

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under which migration takes place vary considerably between individuals and across ethnic groups. It is reasonable to expect that the nature of the diseases investigated has a moderating impact (e.g. immigrants coming from African countries with higher risk for infectious diseases such as Tuberculosis, and lower risks of cardiovascular diseases or cancer). Furthermore, within the framework of the ‘immigrant paradox’, the level of acculturation (e.g. generational status, language use) has been identified as an important influence.

Acculturation is generally defined as the merging of cultures as a result of prolonged contact between individuals and groups of different cultural backgrounds (Crespo et al. 2001; Sam 2006). Thus, acculturation is often described as the process by which immigrants adopt the attitudes, values, customs, beliefs, behaviors, and the lifestyles of a new culture and the dominant society (Abraido-Lanza et al. 2006; Lara et al. 2005). However, researchers have underlined since the 1970s that assimilation is not the only form of acculturation, but that individuals might adopt at least four different approaches towards acculturation including assimilation, biculturalism, separation, marginalization (Berry 1970). Bicultural orientation is characterized as seeking relationships with the host society, while simultaneously maintaining the heritage culture and identity. In contrast, separation is characteristic for individuals who do seek contacts outside their own minority ethnicity, whereas marginalization describes individuals who identify neither with their heritage nor their host society (Berry 2006). Moreover, acculturation is a complex concept that no single factor can adequately describe. When detailed information on culture and attitude is not available, researchers often use more accessible indicators such as place of birth, length of residence in the receiving country, and language preference, either independently or in combination, as proxy measures of acculturation (Lara et al. 2005).

Scientists have argued that acculturation may influence health practices as the acculturation process presents numerous challenges and life changes that could potentially benefit or adversely affect the health behaviors of immigrants as well as subsequent immigrant generations (Abraido-Lanza et al. 2006; Crespo et al. 2001). In accordance with this idea, several studies conducted in the USA have found negative relationships between acculturation and health practices even after adjustment for social disadvantage confounders. That is, research with Hispanic and Asian-American adolescents has implicated acculturation to the US as a risk factor for unhealthy behaviors. For instance, patterns of alcohol abuse, tobacco use, eating disorders, and unhealthy dietary practices were stronger among Mexican Americans who were more acculturated than among those less acculturated (e.g. De La Rosa et al. 2000; Unger et al. 2004).

Regarding the relationship between acculturation and physical activity, Unger et al. (2004) stated that relatively little research has been done. This, however, has changed as research efforts in this area have increased considerably since the turn of the millennium. Based on epidemiological studies showing that ethnic majority populations are generally more active than ethnic minority groups (Epstein et al. 2008; Yeager et al. 1993), researchers have assumed that with increasing acculturation, the level of physical activity approaches the level found in the host population (Hosper et al. 2008). That is, physical activity might differ from other health behaviors and health outcomes, where immigrants have been shown to have a significant advantage over their non-immigrant counterparts (Singh et al. 2008).

Generally, research on acculturation goes beyond descriptive studies which examined ethnic/race differences in physical activity in the sense that acculturation is considered as a potential factor to explain discrepancies. With regard to ethnic differences, previous research in Western countries has shown that (1) ethnic minorities mostly report lower levels of leisure time physical activity (e.g. Crespo et al. 2000; Sagatun et al. 2008), (2) ethnic minorities meet recommendations for weekly leisure-time physical activity to a lower extent than the majority population (e.g. Schoenborn et al. 2004), (3) differences are particularly marked among minority women (e.g. Byrd-Williams et al. 2007) and (4) physical activity of ethnic minorities is influenced by a number of individual-level factors such as socioeconomic status, education, and marital status (Evenson et al. 2003).

Since regular physical activity is an important health resource that reduces health costs and contributes to individual health and well-being (Faulkner and Taylor 2005; Sallis and Owen 1999), it is not surprising that increasing the level of physical activity among ethnic minorities has been identified as an important public health target. Against this background, the present article intends to provide a systematic review over past studies examining the relationship between acculturation and physical activity among immigrants and ethnic minority populations. The following questions will be addressed: First, does past research support a positive influence of acculturation on daily and recreational physical activity? Second, is the evidence independent of the host society in which the study took place, the age, gender and ethnicity of the participants, the date and source of publication, and the methods of data analysis? Third, how strong are the associations between acculturation and physical activity? Fourth, do the findings depend on the measurement of physical activity and acculturation? Fifth, does the temporal sequence of the data allow the establishing of cause–effect relationships? Sixth, is there evidence for a dose–response relationship?

Seventh, can the relationships be maintained if the analyses are controlled for possible confounds? Eighth, does experimental evidence support a causal influence of acculturation on levels of physical activity?

Methods

Review method

The present review is based on narrative synthesis. As outlined in the introduction, acculturation is a complex phenomenon. Moreover, researchers have shown that prolonged length of residence in a host country does not necessarily lead to assimilation, and that individuals might prefer different approaches towards acculturation including biculturalism, separation or marginalization. Given the bidirectional/orthogonal nature of the construct, using a meta-analytic procedure to establish an effect-size for the strength of the relationship between acculturation and physical activity was not appropriate.

Databases searched for this review include Psychinfo/Psyndex, Eric, Pubmed/Medline, Web of Science, and SportDiscus. The last search was carried out in April 2011. We combined the following keywords to search the literature: physical activity, exercise or sport (in the title), and acculturation (in the abstract). In addition to that, citation lists from papers were cross-referenced. Articles selected for inclusion in this review met the following criteria: (1) they were either written in English, German or French; (2) they incorporated (a) a measure of acculturation (e.g. length of residence, language use, adoption of values) as an independent variable, and (b) one or several dependent variables assessing the level of physical activity, exercise, or sport participation as a dependent variable; (3) they provided sufficient statistical information to conclude whether the associations were significant or not; (4) they used measures of leisure-time physical activity (e.g. exercise, sports) and daily physical activity (e.g. household, gardening). Studies that assessed occupational physical activity were excluded because it can be assumed that occupational physical activity is predominantly influenced by type of occupation, and that these activities can be less influenced by individual choice. Thus, the relationship between acculturation and daily and leisure-time physical activity seems more relevant from a public health point of view (BFS 2006).

Our basic hypothesis was that leisure-time physical activity would increase with increasing acculturation. To test this hypothesis, we differentiated between studies that supported, partly supported or did not support significant relationships between acculturation and physical activity. Commonly, multiple indicators were used to assess accul-

turation and physical activity, which is why many studies provided more than one single statistical coefficient. Furthermore, many studies provided several coefficients to compare groups with distinct levels of acculturation against a reference group. To deal with this difficulty, we classified studies with more than 66.6% of significant main effects as ‘supportive’. If 33.3–66.6% of the analyses supported a main effect, studies were considered ‘partly supportive’. If less than 33.3% of the statistics were significant or provided findings non-compliant with our hypothesis, the studies were classified as ‘non-supportive’. Although these cut-off criteria might seem arbitrary, we argue that using three equally broad categories allows the most balanced interpretation of the findings. Additionally, we have indicated for each study the ratio of significant coefficient in relation to the total number of tests of significance (Table 1). In some studies, unadjusted and adjusted analyses were provided. In this case, the analyses with the higher level of adjustment were used to establish the significance of effects. Despite using the 5% level of significance as a cut-off criterion, this review does not purely rely on a vote-counting procedure. Vote-counting may be a problematic approach that may entail misleading conclusions (e.g. no validity concerns, reliance of sample size). Accordingly, we employed Hill’s (1965) criteria (consistency, strength of associations, specificity of effects, temporality, gradient, plausibility and experimental evidence) in order to determine more solidly to what degree the association between acculturation and physical activity can be regarded as causal.

Specifically, Hill (1965) argued that an association between constructs can be viewed as more evidence-based if it has been observed repeatedly over time by different researchers, in different places, in different circumstances and times, and by using different methodological approaches. Accordingly, consistency refers to the issue of external validity, that is, to the degree of generalizability of effects across individuals and methodologies. Thus, we examined whether supportive findings were found (1) in different countries, (2) in different age groups, (3) in female versus male subjects, (4) in different ethnic minority groups, (5) in different moments in time, (6) including populations with small versus large sample sizes, and (7) using different methods of data analysis. Moreover, Hill (1965) emphasized that the strength of association is an important indicator of causality because it shifts attention from interpreting levels of significance towards meaning and relevance of empirical data. Additionally, specificity strengthens the plausibility of cause–effect relationships. As an example, Hill (1965) argued that specificity of effects refers to whether a specific disease (e.g. lung cancer) is limited to specific conditions thought to be responsible for this disease (e.g. smoking). Referring to specificity, we

Table 1 Overview of studies classified as supportive, partly supportive and non-supportive

Supportive studies		Partly supportive studies		Non-supportive studies	
Pérez-Stable et al. 1994	100.0%	Lee et al. 2000	37.5%	Cantero et al. 1999	0.0%
Crespo et al. 2001	66.7%	Richman et al. 2000	50.0%	Carvajal et al. 2002	0.0%
Song et al. 2004	66.7%	Evenson et al. 2004	44.4%	Gordon-Larsen et al. 2003	16.7%
Hosper et al. 2007	100%	Abraido-Lanza et al. 2005	50.0%	Wilbur et al. 2003	0.0%
Corral and Landrine 2008	100%	Dergance et al. 2005	40.0%	Unger et al. 2004	0.0%
Neighbors et al. 2008	75.0%	Kandula and Lauderdale 2005	44.4%	Dawson et al. 2005	25%
Singh et al. 2008	66.7%	Berrigan et al. 2006	50.0%	Slattery et al. 2006	20%
Liu et al. 2009	66.7%	Tremblay et al. 2006	64.3%	Crespo et al. 2006	0.0%
Dogra et al. 2010	75.0%	Wolin et al. 2006	37.5%	Fitzgerald et al. 2006	0.0%
		Allen et al. 2007	50.0%	Marquez et al. 2006	0.0%
		Pichon et al. 2007	50.0%	Masel et al. 2006	0.0%
		Choi et al. 2008	50.0%	Yang et al. 2007	0.0%
		Hofstetter et al. 2008	50.0%	Mainous et al. 2008	0.0%
		Hosper et al. 2008	50.0%	Martinez et al. 2008	11.1%
		Renzaho et al. 2008	51.9%	Mejean et al. 2009	0.0%
		Springer et al. 2009	33.3%	Chen 2009	0.0%
				Afable-Munsuz et al. 2010	21.4%
				Ghaddar et al. 2010	25%
				Taverno et al. 2010	25%
9 studies		16 studies		19 studies	

Note: Multiple samples and indicators of acculturation and leisure-time physical activity were used in most studies. Therefore, studies with $0 < 33.3\%$ of supportive findings were classified as non-supportive, studies with $\geq 33.3\text{--}66.6\%$ of supportive findings as partly supportive and studies with $\geq 66.6\%$ of supportive findings as supportive. The exact percentage of supportive findings is indicated after each study. More detailed information about the total number of analyses in each study is provided in Table 2.

examined whether positive associations between acculturation and physical activity existed independent of the physical activity and acculturation measures. Furthermore, the criterion of temporality is closely connected with issues regarding the internal validity of the study design. Following Hill (1965), temporal sequence addresses the question of “which is the cart and which the horse” (p. 297), and might hence answer whether individuals become more physically active as they get more acculturated or whether physical activity might contribute to the acculturation of individuals. As generally accepted, temporal sequence can only be tested through prospective, longitudinal or experimental studies. What Hill (1965) called a gradient is currently known as a dose-response relationship. In our review, two aspects are of particular interest, (1) whether an increase in acculturation results in linearly increasing physical activity and (2) whether physical activity increases more strongly if individuals report high scores on multiple acculturation indicators (e.g. second generation immigration status in combination with high language proficiency). The concept of plausibility refers to the question of whether particular mechanisms can convincingly explain the positive relationships between acculturation and physical activity. Therefore, we examined

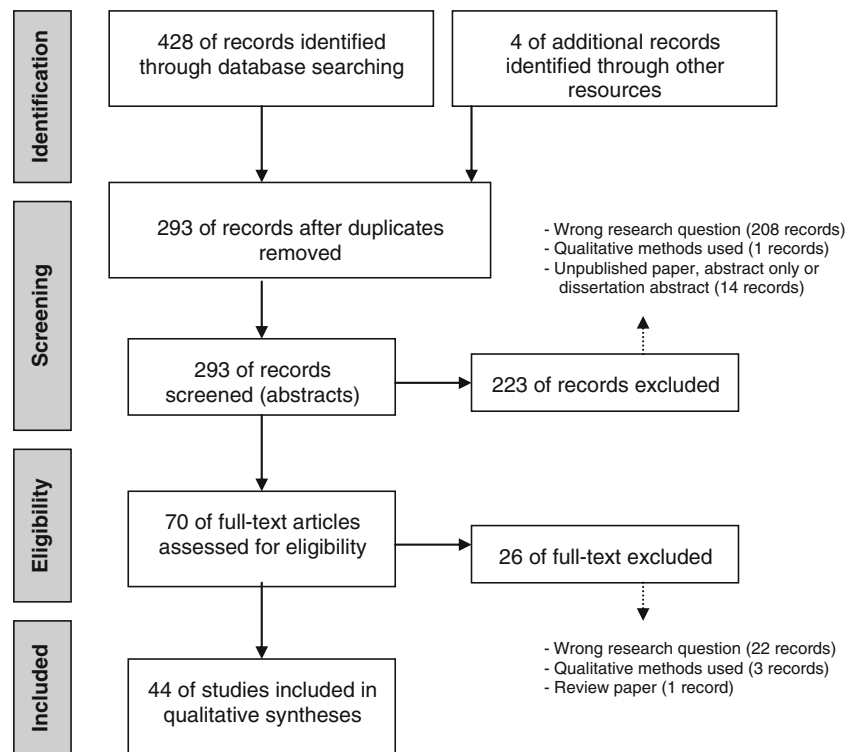
whether previous analyses were sufficiently controlled for potential confounds, and whether the associations are moderated by environmental factors. Finally, Hill (1965) argued that the best evidence for a causal link might come under the criterion of experimental evidence. The last question is therefore, if it is possible to observe (experimentally induced or naturally occurring) circumstances that lead to changed patterns between acculturation and physical activity.

Results

Studies included in the review

Forty-four studies dealing with the relationship between acculturation and physical activity among ethnic minority groups were found that met all the aforementioned inclusion criteria. Figure 1 provides a flow chart of how the studies were screened, assessed for eligibility, and included in the review. The review includes a total of 760,242 participants. Table 1 indicates which studies were classified as supportive, partly supportive and non-supportive. Detailed information about the samples, sam-

Fig. 1 Overview of the study selection process following the PRISMA Statement (Moher et al. 2009)



pling methods, research designs, control of confounding variables, measurements and data-analysis techniques and the results is provided in Table 2 (listed in chronological order, and alphabetical order if several studies were published in the same year). In addition, Table 2 provides the ratio of significant/total tests of significance for each single study.

Nine studies supported the hypothesis that increased acculturation is associated with higher leisure time and daily physical activity (see Table 1). In addition, 16 studies showed partial support. In contrast, 19 studies did not confirm a main effect between acculturation and physical activity. Among the non-supportive studies, four investigations provided contradicting results in the sense that higher acculturation was related to decreased physical activity (Berrigan et al. 2006; Cantero et al. 1999; Marquez and McAuley 2006; Unger et al. 2004).

Criterion 1: consistency of evidence

Location Previous studies have been carried out in the USA, Canada, Sweden, the Netherlands, Australia and France. Positive relationships between acculturation and daily/leisure time were found both in North American (eight studies supportive, 13 partly supportive), European (one study supportive, one study partly supportive) and Australian research (two studies partly supportive). Interestingly, in other parts of the world, no attempts have been made to examine this issue.

Participants' age Most research has been conducted with adults (31 studies). Only eight studies have focused on children and adolescents. Adult studies provided 61% supportive findings (six supportive, 13 studies partly supportive studies), whereas among children and adolescents 63% of prior research showed supportive results (two supportive, three partly supportive studies). Non-supportive findings were found in studies with younger children (Crespo et al. 2006; Martinez et al. 2008; Taverno et al. 2010; Unger et al. 2004) and older adolescents (Carvajal et al. 2002; Gordon-Larsen et al. 2002). Research with elderly people is rare, but indicates that acculturation is less influential in older age (Cantero et al. 1999; Masel et al. 2006; Mejean et al. 2009), although positive findings were reported with elderly Mexicans (Dergance et al. 2005) and Koreans (Richman et al. 2000).

Gender differences Eight studies exclusively focused on female samples (Cantero et al. 1999; Choi et al. 2008; Evenson et al. 2004; Fitzgerald et al. 2006; Hosper et al. 2008; Pichon et al. 2007; Slattery et al. 2006; Wilbur et al. 2003), whereas one study only focused on men (Mejean et al. 2009). All other investigations used mixed samples. Among female studies, 50% of the investigations were partly supportive, whereas 50% of the studies did not find significant relationships. The only study focusing on males was not supportive (Mejean et al. 2009). Most investigations with mixed samples did not identify major differences between men and women. Gender sensitive analyses,

Table 2 Summary of studies, in descending order by year of publication

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Pérez-Stable et al. 1994, USA	Hispanic sample ($n=1,236$, $m=565$, $f=671$, 18–65 years, $M \approx 38$ years, Latinos, non-Latino whites, San Francisco)	Cross-sectional (random digit-dialing, telephone interviews, controlled for sex, education, age and employment status)	Logistic regression 1. Level of acculturation ^a 2. Sedentary life-style ^b	Acc. $\uparrow \diamond PA \uparrow$ \rightarrow Supportive (100%, 1/1)	Whites less sedentary than Latinos among men and women Odds ratio of 2.1 of less acculturated Latinos for reporting sedentary life-style compared to more acculturated individuals
Notes:					
^a Unidirectional acculturation scale (Short Acculturation Scale for Hispanics), five items, comparison of less acculturated (scores 1 to < 3) and more acculturated individuals (scores ≥ 3)					
^b Sedentary life-style defined as no LTPA					
Cantero et al. 1999, USA	Hispanic women ($n=573$, 46–92 years, Latinas, recruited from publicly subsidized housing projects in Los Angeles, mostly low educational level)	Cross-sectional (interviews in preferred language, bilingual interviewers, <i>To Your Health Project</i> : 1984/1985 data, 64% response rate)	Chi-square test	Acc. $\uparrow \diamond PA \downarrow$	Acculturation negatively affected health practices of middle-aged Latinas (smoking, alcohol, exercise). The effects were stronger among Latinas aged <65 years than among individuals aged 65–74 years. Acculturation was unrelated to healthy practices among elderly women (≥ 75 years)
Notes:					
^{1a} Language use ^a					
^{1b} Length of residence in USA ^b					
2. Exercise ^c					
^a Language acculturation scale (11 items) including first language learned, understanding of spoken and written English, preferred language with spouse, children and friends and for books, newspapers, radio stations and TV programs, validity and reliability established, comparison of women with low, medium and high scores (trichotomization)					
^b Born in USA, ≤ 25 years vs. > 25 years in USA					
^c Single item referring to the amount of exercise, comparison of women with no regular exercise (at best exercise during housework or chores), occasional exercise (occasionally walk for exercise) vs. regular exercise (do exercise on regular basis; 2–3 times per week)					
Lee et al. 2000, USA	National sample ($n=356$, approx. 40% women, $M=40.8$ years, Korean Americans)	Cross-sectional (stratified sampling by region, urban/rural residence, age, gender, mailed survey, 55% response rate)	Logistic regression	Acc. $\uparrow \diamond PA \uparrow$ (2a) Acc. $</> PA$ (2b) \rightarrow Partly supportive (38%, 3/8)	Acculturated men with higher low intensity PA than bicultural and traditional men. Acculturated and bicultural women with higher low intensity PA than traditional women Odds ratio of 4.3 (men) and 7.4 (women) of traditional Korean Americans for reporting low light PA compared to more acculturated individuals
Notes:					
^a Bidirectional approach towards acculturation, distinguishing structural and cultural acculturation, no information about number of items, validity and reliability provided, cluster analyses revealed acculturated, bicultural, and traditional groups					
^b Frequency of light physical activity, ≥ 2 times/week (e.g. walking, dancing, gardening, golfing)					
^c Frequency of vigorous exercise or sports, ≥ 2 times/week (e.g. aerobics, running, swimming, bicycling)					

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Richman et al. 2000, AUS	Elderly Koreans ($n=99$, $m=41$, $f=58$, $M=72-75$ years, Koreans living in Seoul and Koreans emigrated to Australia)	Cross-sectional (subjects recruited via community neighborhood centers, interviews and questionnaire)	ANOVAs and correlations	Acc. $\uparrow </>$ PA \uparrow (2a)	86% of Australian Koreans were physically active, compared to 53% of Koreans living in Seoul. No significant Gender \times Country interactions found
			1. Generational status ^a 1b. Length of residence in AUS ^b 2. LTPA and daily PA ^b	Acc. $</>$ PA (2b) \rightarrow Partly supportive (50%, 1/2)	Among Australian Koreans, physical activity was not correlated with length of residence in Australia
Notes:					
^a Comparison of Koreans living in Seoul compared to Koreans who have immigrated to Australia					
^b Number of years lived in Australia					
^c Two-week recall including walking to vigorous LTPA and daily PA					
Crespo et al. 2001, USA	National representative sample ($n=4,893$, $m=2,467$, $f=2,426$, Mexicans, aged ≥ 20)	Cross-sectional (multistage, stratified survey, bilingual interviewers, oversampled for Mexican Americans and Blacks, NHANES III, controlled for age, education and income)	Logistic regression	Acc. \uparrow (1a/b/c) $</>$ PA \uparrow	Inactivity lower among English than non-English speakers across men and women. Men and women born in Mexico with higher inactivity than US-born Mexicans
			1a. Language use at home ^a 1b. Place of birth ^b 1c. Length of residence in USA ^c 2. LTPA ^d	\rightarrow Supportive (67%, 4/6)	Odds ratio of 1.5 (Spanish), 1.8 (bilingual), 1.7 (<5 years), 1.4 (5–9 years), 1.5 (10–19 years) and 1.3 (≥ 20 years) of less acculturated Mexicans for physical inactivity compared to more acculturated individuals (English-speakers, US-born)
Notes:					
^a English, both Spanish and English vs. Spanish					
^b Born in USA vs. born in Mexico					
^c Born in USA, <5 years, 5–9 years, 10–19 years vs. ≥ 20 years in USA					
^d Eight specific LTPAs during past month and four open-ended questions, individuals with responding “no” on all questions were classified as inactive					
Carvajal et al. 2002, USA	Middle school students ($n=1,119$, Latino youth, northern California)	Cross-sectional (random sample, survey in English or Spanish, 65% response rate)	Logistic regression 1. Level of acculturation ^a 2. Exercise participation ^b	Acc. $</>$ PA \rightarrow Not supportive (0%, 0/3)	Latinos more likely to report physical inactivity than non-Latino whites across both genders
Notes:					
^a Two orthogonal acculturation scales to assess degree of Latino orientation and other group orientation, 7 items per scale, based on Bidimensional Acculturation Scale for Hispanics (Marin and Gamba 1996) and Acculturation Rating Scale for Mexican Americans II (Cuellar et al. 1995), including several domains with focus on language and social interaction, validity and reliability established, comparison of bicultural, Latino-focused, other focused, and marginalized adolescents by means of median split					
^b Active adolescents (participation in heavy exercise on ≥ 4 days or lighter exercise on ≥ 5 days in past week) vs. inactive adolescents					
Gordon-Larsen et al. 2003, USA	National representative sample ($n=8,613$, $m=4,267$, $f=4,346$, $M=15.9$ years, non-Hispanic Whites, Mexicans, Puerto Ricans, Cubans, grades 7–12)	Cross-sectional (interviews, <i>National Longitudinal Study of Adolescent Health - Add Health: 1995/1996</i> data)	Logistic regression	Acc. (1a) $</>$ PA (2a/b)	Few effects found for generational status. Exception: Second generation Mexicans reported more low intensity PA than first generation peers
			1a. Generational status ^a 1b. Language spoken at home ^b	\rightarrow Not supportive (17%, 1/6)	Language spoken at home and length of residence in USA not examined as a potential influences (only covariates)

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Notes:					
^a Generation one (child foreign-born), generation two (child born in USA with one or both parents born abroad) vs. generation three (child born in USA with both parents born in USA)					
^b English vs. non-English					
^c Recent (0–5 years) vs. established immigrants (6–10 years)					
^d 7-day PA recall, activity reported in bouts per week, MVPA 5–8 MET, light intensity PA 2–3 MET (including house cleaning, hobbies, and hanging out with friends)					
Wilbur et al. 2003, USA	Hispanic women ($n=300$, 20–50 years, $M=32.3$ years, 92% Mexicans, Chicago, 81% born outside USA, urban-dwelling sample, volunteers)	Cross-sectional (interview in preferred language, <i>Women and Physical Activity Survey</i> , controlled for age, education, income, marital status, children at home, general health)	Logistic regression 1a. Place of birth ^a 1b. Length of residence in the USA ^b 1c. Language spoken at home ^c 1d. Language preference ^d 2. MVPA recommendations ^e	Acc. (1a/b/c/d) </> PA → Not supportive (0%, 0/16)	36% of the women met current MVPA recommendations, 52.3% were insufficiently active, and 11.7% were inactive
Notes:					
^a Born in vs. outside USA					
^b Born in USA, <5 years, 5–9 years, 10–19 years vs. ≥20 years in USA					
^c Spanish, both English and Spanish vs. English					
^d Preferred language in four different situations, four items, ranging from only Spanish to only English, validity and reliability established					
^e Items from BRFS survey including lifestyle activity and exercise: Comparison of women who meet recommendations (≥5 days/week moderate activity for 30 min or ≥3 days/week vigorous activity for 20 min), women who are insufficiently active (some activity, but below recommended level) vs. inactive women (no moderate or vigorous activity)					
Evenson et al. 2004, USA	First generation immigrant women ($n=671$, 20–50 years, Hispanics, North Carolina)	Cross-sectional (face-to-face interviews in Spanish language, bilingual interviewers, controlled for age, general health, children, marital status, education, fatalism and driving license)	Logistic regression 1a. Language usage ^a 1b. Length of residence in the USA ^b 1c. Age at arrival in the USA ^c 2. MVPA recommendations ^d	Acc. ↑ (1a/c) < PA ↑ Acc. (1b) </> PA → Partly supportive (44%, 8/18)	62% of participants did not adhere to MVPA recommendations Increased length of residence did not result in more MVPA, if language acculturation remained low. Women who lived in the USA for more than 3 years about twice as likely to fulfill MVPA recommendations if they had high language acculturation scores
Notes:					
^a Unidirectional language preference scale including different situations (Marin et al. 1987) ranging from only Spanish to only English, 4 items					
^b Recent (<3 years) vs. more established immigrants (≥3 years)					
^c Younger (<25 years) vs. older immigrants (≥25 years)					
^d MVPA defined as any moderate activity for at least 10 min at a time such as brisk walking, bicycling, vacuuming, gardening that causes some increase in breathing or heart rate in a usual week (excluding occupational activity), frequency and total time assessed, comparison of women who meet recommendations (≥5 days/week MPA for 30 min or ≥3 days/week VPA for 20 min), women who are insufficiently active (some PA, but below recommended level) vs. inactive women (no MVPA)					
Song et al. 2004, USA	Representative sample ($n=3,330$, $m=1,582$, $f=1,748$, >18 years, Korean-Americans living in California and Koreans living in Seoul)	Cross-sectional (random sample, telephone interviews in preferred language, 86% completion rate for Korean-Americans and 50% for Seoul-Koreans, controlled for age)	Logistic regression 1a. Generational status ^a 1b. Level of acculturation ^a 2. VPA ^b	Logistic regression Acc. ↑ < PA ↑ → Supportive (67%, 4/6)	Odds ratio of 0.7 (traditional males), 0.4 (traditional women), 1.8 (acculturated males) and 1.8 (acculturated women) to report high exercise compared to Koreans living in Seoul

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
<p>Notes:</p> <p>^aComparison of Koreans living in Seoul with Korean-Americans with traditional, bicultural and acculturated orientation (based on cluster analysis), Suinn-Lew Asian Self-Identity Acculturation Scale (SL-ASIA), 14 items, validity and reliability established, including language, identity, friendships, behaviors, generational/geographic background, and attitudes</p> <p>^bEpisodes of vigorous LTPA during a typical week for ≥ 20 min, comparison of individuals with < 3 vs. ≥ 3 weekly episodes</p>					
Unger et al. 2004, USA	Middle school students ($n=2,004$, Asian-Americans, Hispanics, $M=11.2$ – 11.4 years, urban and ethnically diverse sample, southern California)	Prospective from grade 6 to grade 7 (survey, 68.8%, controlled for age, gender, SES, parents' education, language usage)	Stepwise regression 1a. Level of acculturation ^a 1b. Language usage ^b 2. MVPA ^c	Acc. \uparrow (1a) \diamond PA \downarrow Acc. (1b) $</>$ PA \rightarrow Not supportive (0%, 0/2)	Acculturation associated with lower PA participation for boys and girls ($\beta = -.09$)
<p>Notes:</p> <p>^aBidirectional acculturation scale (AHIMSA Acculturation Scale for Adolescents: Unger et al. 2002), 8 items, including several domains, forced choice between US, country of my family is from, both, neither, validity and reliability established, separate biculturalism, country of origin, marginalization and US orientation scales, only US orientation used in this study</p> <p>^bLanguage most frequently spoken in general and at home, 1 item, ranging from English only to another language only</p> <p>^cFrequency of participation in exercise, sports or PA ≥ 20 min causing sweating or increased breathing, 1 item</p>					
Abraido-Lanza et al. 2005, USA	National representative sample ($n=36,401$, age ≥ 18 years, Latinos vs. non-Latinos)	Cross-sectional (interview with bilingual interviewers, <i>National Health Interview Survey</i> : 1991 data, 95.7% response rate, controlled for age and SES)	Logistic regression	Acc. \uparrow \diamond PA \uparrow (women) Acc. $</>$ PA (men)	Latinos less likely to engage in exercise activities, but reported less smoking and alcohol consumption Higher acculturation was associated with higher alcohol intake, smoking and BMI
<p>Notes:</p> <p>^aLow acculturation (foreign-born and in the USA for < 15 years) vs. high acculturation (US-born or foreign-born but for ≥ 15 years in USA)</p> <p>^bLeisure-time physical inactivity defined as engagement in any physical fitness or sport activities during the past two weeks</p>					
Dawson et al. 2005, SWE	Nationwide sample ($n=14,485$, $m=7,172$, $f=7,313$, approx. 90% Swedish, Western Europe, Finland, Southern Europe, Eastern Europe, other countries, 20–74 years)	Cross-sectional (random sample, face-to-face or telephone interviews in Swedish or mother tongue, <i>Swedish Survey of Living Conditions</i> : 1996, 1997, 1999 data, 78.7% response rate, controlled for age, BMI education, smoking, long-term illness and disability)	Logistic regression	Acc. \uparrow \diamond PA \uparrow (women) Acc. $</>$ PA (men)	41% of women and 43% of men with no/very occasional LTPA. Participants from Finland (men only), Eastern Europe (women only), Southern Europe and other countries more likely to be physically inactive than Swedish referents Gradient observed between increasing length of time since immigration to Sweden and increasing LTPA in women Odds ratio of 2.0 (< 5 years), 1.7 (5–9 years), 1.4 (10–14 years) and 1.0 (15–19 years) for being physically inactive of more recent immigrants compared to the most established referents (≥ 20 years)

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Dergance et al. 2005, USA	Community-based sample ($n=749$, $m=317$, $f=432$, ≥ 65 years, Mexican Americans and European Americans, community-dwelling sample)	Cross-sectional (random sample, questionnaire in preferred language, <i>San Antonio Longitudinal Study of Aging</i> , 65.3% response rate controlled for age, sex, SES)	Logistic regression	Acc. (1e) $\uparrow < \Delta$ PA \uparrow Acc. (1a/b) $</>$ PA \rightarrow (40%, 4/10)	European-Americans expend almost 300 kcal/week more energy than Mexican-Americans Odds ratio of 2.4 to be physically active of immigrants with high structural assimilation compared to individuals with low scores
Notes:					
^a Foreign-born, recent (<5 years) vs. more established immigrants (5–9 years, 10–14 years, 15–19 years, ≥ 20 years)					
^b File possible categories: No LTPA, very occasional LTPA, regular LTPA 1 time/week, regular LTPA \geq twice/week or regular strenuous LTPA \geq twice/week. Comparison of individuals with no/very occasional activity vs. regular LTPA ≥ 1 time/week					
^c Extent to which the preservation of Mexican history, holidays, customs, and ways of living are valued					
^d Extent to which traditional extended family structure and sex-role organization are valued					
^e Entrance into the social structure of the host society including friendship, and contacts at school, neighborhood or workplace					
^d <i>Minnesota Leisure Time Physical Activity Questionnaire</i> including household, yard/lawn work, walking, and organized sports/recreational activities, kilocalories of energy expended per week					
Kandula and Lauderdale 2005, USA	Statewide sample with oversampling of Asians ($n=32,764$, $m=13,948$, $f=18,816$, Asian Americans, 18–59 years, California)	Cross-sectional (random-digit dialing, telephone interviews in English or Asian language, <i>California Health Survey</i> , 64% response rate, controlled for age, marital status, health status, English language use at home, BMI, and urban residence)	Logistic regression	Acc. \uparrow (1a/b) $< \Delta$ PA \uparrow (2a/c) Acc. (1a/b) $</>$ PA (2b) \rightarrow Partly supportive (44%, 8/18)	Asians (men and women) less likely to meet LTPA recommendations and more likely to be physical inactive than US-born non-Asians Foreign-born Asians least likely to participate in LTPA. LTPA increased as years in the US increased Odds ratio of 0.5 (men) and 0.3 (women) to meet LTPA recommendations of recent immigrants compared to US-born Asian Americans. Odds ratio of 1.7 (men) and 2.5 (women) of recent immigrants to be physically inactive Place of birth and length of residence in the USA more closely related to LTPA among women than men
Notes:					
^a Recent (0–4 years) vs. more established immigrants (5–9 years, ≥ 10 years)					
^b Speaking English vs. Asian language at home, 1 item					
^c Frequency and duration of VPA during free time including exercise, sports, and physically active hobbies (walking, biking excluded; activities causing heavy sweating or large increases in breathing/heart rate) or MPA (causing light sweating or slight to moderate increases in breathing/heart rate) for at least 10 min during the past 30 days, comparison of individuals who meet LTPA (≥ 5 days/week MPA for 30 min or ≥ 3 days/week VPA for 20 min), NLTPA (≥ 5 days/week walking/biking for 30 min) and who are physically inactive (< 10 min/week of LTPA or NLTPA)					
^d Frequency and duration of walking or bicycling to/from work during past 30 days					
Berrigan et al. 2006, USA	National representative sample ($n=4,558$, $m=2,265$, $f=2,293$, ≥ 18 years)	Cross-sectional (multistage, random sample, 2000 <i>National Health</i>)	Logistic regression	Acc. $\uparrow < \Delta$ PA \uparrow (2a)	With increasing acculturation, adherence to recommendations concerning LTPA

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
	years, Hispanic adults)	<i>Interview Survey</i> , controlled for gender, age, education, income, employment, marital status, urban residence and BMI)	1. Language use ^a 2a. LTPA recommendations ^b 2b. Walking and cycling for errands and to/from work ^c	Acc. ↑ < PA ↓ (2b) → Partly supportive (50%, 2/4)	increased from 23% to 47% from the least to the most acculturated fertile, and decreased from 25% to 18% for walking or bicycling for errands and to/from work Odds ratio of 1.8 and 3.0 to meet LTPA recommendations of migrants with medium or high acculturation compared to individuals with low scores. Odds ratio of 0.7 to walk/bike for errands of migrants with medium/high acculturation
Notes:					
^a Language acculturation scale (8 items) including first language learned, understanding of written English, preferred language at home and with friends and for TV and radio programs, validity and reliability established, comparison of participants with low, medium and high scores (trichotomization)					
^b Frequency and duration of light, moderate and vigorous physical activities during leisure time. Comparison of individuals who meet LTPA (≥60 min of vigorous activity or ≥150 min of light or moderate activity per week)					
^c Walking or bicycling to/from work/school or to do errands (yes/no)					
Crespo et al. 2006, USA	Overweight Hispanic children (n = 144, m = 78, f = 66, 8–13 years, ≥85th percentile of age- and gender-specific BMI, family history of diabetes, Los Angeles)	Cross-sectional (recruited through medical referrals, advertisements and word of mouth, <i>Study of Latino Adolescents at Risk for Type 2 Diabetes project</i> , controlled for age, gender, SES, total fat mass, total lean tissue mass)	ANCOVA 1a. Place of birth ^a 1b. Level of acculturation ^b 2a. LTPA ^c 2b. Number of sports in school per year 2c. Number of sports outside school per year	Acc. (1a/b) < PA (2a/b/c) → Not supportive (0%, 0/6)	After adjustment for covariates, second and third generation children had higher VO2max than first generation and foreign-born children
Notes:					
^a Foreign-born (child and both parents foreign-born), generation one (child US-born, both parents foreign-born), generation two (child born in USA with one parent born abroad) vs. generation three (child born in USA with both parents born in USA)					
^b AHIMS acculturation scale for adolescents including cultural preferences of friends, music, TV shows, and foods, 8 items, validity and reliability established, only assimilation scores were used, comparison of children with high and low scores					
^c Recall of time spent for various types of activities including walking, running, playing sports					
Fitzgerald et al. 2006, USA	Puerto Rican women (n = 200, 15–62 years, M = 29 years, low-income Connecticut)	Cross-sectional (convenience sample, interviews in language of choice, controlled for BMI, SES, smoking, alcohol)	Logistic regression 1. Primary language spoken at home and self-rated English proficiency ^a 2. Exercise participation ^b	Acc. < PA → Not supportive (0%, 0/1)	Although not significant, a tendency was found that more acculturated individuals are more physically active Odds ratio of 0.5 of women with low acculturation status to be physically active compared to women with high acculturation levels
Notes:					
^a Comparison of individuals with low acculturation status (speaks Spanish only or not fluent in English) vs. high acculturation status (speaks English only or both languages, and fluent in English)					
^b Participants considered physically active if they exercise ≥3 times/week for half an hour each time					
Marquez and McAuley 2006, USA	Latino men and women (n = 155, m = 69, f = 86, 18–60 years, M = 29.4 years, Hispanics from 15 countries, 45% Mexican)	Cross-sectional (non-random sample, survey, recruited via health centers, housing complexes and employment agencies, 72.8%)	Correlations 1. Level of acculturation ^a	Acc. < PA (2a/c/e) Acc. ↑ < PA ↓ (2 d)	Men reported more PA (daily counts, overall PA) than women. Women with more household PA Recreational and household PA significant

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Masel et al. 2006, USA	(n=2,167, ≈ 58% women, ≥65 years, Mexican-Americans, Texas, New Mexico, Arizona, Colorado, California)	response rate) Cross-sectional (survey in preferred language, <i>Hispanic Established Populations for the Epidemiologic Studies of the Elderly</i> : 1992–1996 data, controlled for age, education, sex, income, marital status, BMI and health)	2a. Recreational PA 2b. Household PA ^b 2c. Overall PA ^b 2d. Daily activity counts ^c	→ Not supportive (0%, 0/4)	predictors of overall accelerometer counts Acculturation weakly related to overall PA (r=-.23), but not to recreational PA and daily activity counts
Notes:					
^a Unidirectional acculturation scale (<i>Short Acculturation Scale for Hispanics</i> : Marin et al. 1987) including several domains ranging from only Spanish/all Latinos to only English/all Americans, 12 items					
^b <i>EPIC Physical Activity Questionnaire</i> (Wareham et al. 2002), including scores of overall PA derived from several subcategories, estimation of energy expenditure (MET h/week) performed					
^c Daily activity counts were monitored with a portable actigraph, validity established previously, days with more than 12 hours of missing data were excluded					
Hierarchical regression 1a. Place of birth ^a 1b. Language use ^b 1c. Social contacts ^c 2. LTPA ^d					
Acc. (1a/b/c) </> PA → Not supportive (0%, 0/3)					
Notes:					
^a Foreign-born vs. US-born					
^b English language competency in reading, writing, understanding, and speaking English, frequency of English use, frequency of use of TV and radio programs in English					
^c Ethnic composition of friends and neighbors					
^d <i>Physical Activity Scale for the Elderly</i> (PASE), scores from 0–400					
Slattery et al. 2006, USA	Hispanic women (n=2,039, 25–79 years, Hispanics, non-Hispanic Whites, Arizona, Colorado, New Mexico, Utah)	Cross-sectional (random sample, computerized questionnaire in English or Spanish, controls from a large case-control study, survey, 4- <i>Corner's Breast Cancer Study</i>)	Logistic regression 1. Language preference ^a 2a. Household ^b 2b. Yard work ^b 2c. Sports/conditioning activities ^b 2d. Total MET ^b 2e. Vigorous MET ^b 2f. Lifetime physical activity ^c	Acc. ↑ < > PA ↑ (2c/d/e) Acc. </> PA (2a/b/f) → Not supportive (20%, 4/20)	The majority of both Hispanic (75%) and non-Hispanic white women (65%) did not accomplish activity recommendations Hispanic women reported more household, dependent care giving, dancing, and work activity than non-Hispanic Whites Hispanic women more likely to report regular activity if they had high language acculturation levels (28.4%), compared to women with intermediate (26.2%) or low acculturation levels (13.6%)
Notes:					
^a Preference for speaking and reading Spanish, 2 items, ranging from Spanish only to English only					
^b Adaptation of <i>Cross-Cultural Activity Participation Study Questionnaire</i> (Ainsworth et al. 2000) developed for minority women, including frequency, duration and intensity of household activities, gardening/yard work, walking, and sports/conditioning activities					
^c Average of activity at ages 15, 30, 50 and during the referent period					
Tremblay et al. 2006, CAN	National representative sample (n=171,513, 20–64 years, multiethnic)	Cross-sectional (survey, <i>Canadian Community Health Survey</i> ,	Logistic regression	Acc. ↑ < > PA ↑	Gradient in the prevalence of being enough physically active found with

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Pichon et al. 2007, USA	Heterogeneous Latina sample ($n=547$, $M=34.0$ years, San Diego, no major health problems, mothers/female caregivers)	Cross-sectional (random sample, survey in English or Spanish language, 80.8% response rate, controlled for education and marital status)	1b. Social contacts with ethnic Dutch ^b 2a. LTPA ^c	2/2)	less strong among people who had children, who lived in a less attractive neighborhood or who engaged in occupational PA
Notes:					
^a Unidirectional acculturation scale (10 items, Dutch orientation scale) including questions about language use, shopping preferences, use of media, difficulties with reading Dutch and emancipation, comparison of upper third with lower two thirds)					
^b Contacts with ethnic Dutch during leisure time, 3 items					
^c Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH; Wendel-Yos et al. 2003) including questions about sports and other leisure time PAs (e.g. walking, cycling, gardening), comparable to the IPAQ, frequency and duration used to estimate MET scores, participants classified as active if ≥ 30 min (or 60 min if under 18 years) of MPA per session ≥ 1 day/week					
Only 30% of Latinas meet VPA criteria, 8.6% met MPA and 46.4% met walking					
No direct association of neighborhood safety/aesthetics found with any PA measures. Neighborhood safety/aesthetics did not mediate between acculturation and PA					
Weak direct relationships between Anglo acculturation, MPA ($\beta = .14$) and VPA ($\beta = .17$) and Mexican acculturation and VPA ($\beta = -.25$)					
Notes:					
^a Bidirectional acculturation scale (<i>Acculturation Rating Scale for Mexican Americans II</i> ; Cuellar et al. 1995), including several domains ranging from not at all English/Spanish to almost always English/Spanish, 30 items, separate Anglo and Latino orientation scales available					
^b Short version of the <i>International Physical Activity Questionnaire</i> , frequency and duration of walking, moderate intensity, and vigorous intensity PA during past 7 days					
Yang et al. 2007, USA	Midlife Korean American women ($n=152$, $M=47.0$ years, mostly married and protestant, central Texas)	Cross-sectional (participants recruited via flyers and church activity groups (self referrals), questionnaire in preferred language, 46% response rate, controlled for age, education, income, marital status, cognitive and social exercise determinants)	Hierarchical regression analysis 1. Level of acculturation ^a 2. LTPA ^b	Acc. $</>$ PA → Not supportive (0%, 0/1)	In total, 32% of the participants not engaged in any form of exercise Significant relationships between acculturation and physical activity neither found in correlation analyses nor in hierarchical regression analyses
Notes:					
^a Suinn-Lew Asian Self-Identity Acculturation Scale (SL-ASIA), 14 items, validity and reliability established, including language, identity, friendships, behaviors, generational/geographic background, and attitudes					
^b Kaiser Physical Activity Survey (KPAS), 42 items, validity established					
Choi et al. 2008, USA	Midwestern Korean immigrant women ($n=188$, $M=41$ years, 18–64 years, Koreans born abroad, majority with college degree, no children and married)	Cross-sectional (convenience sample, recruited through key informants, religious leaders and churches, controlled for age, marital status, children, education and income)	Correlations	Acc. \uparrow (1b) $<$ PA \uparrow Acc. (1a) $</>$ PA → Partly supportive (33%, 1/3)	78% met the Healthy People 2010 goal for physical activity, hereof 23% with LTPA only Correlation between length of residence and LTPA relatively weak ($r=-.23$)

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
<p>Notes:</p> <p>^a<i>Yanconver Index of Acculturation</i>, 20 items, two subscales (heritage, mainstream), validity and reliability established</p> <p>^bYears of stay in the USA since immigration</p> <p>^c<i>International Physical Activity Questionnaire</i>, LTPA</p>					
Corral and Landrine 2008, USA	Statewide sample ($n=7,249$, $m=3,045$, $f=4,172$, ≥ 18 years, $M=38.6$ years, Mexicans, California)	Cross-sectional (random sample, telephone interviews, <i>California Health Interview Survey</i> , controlled for age and SES)	Logistic regression	Acc. \uparrow (1a/b) $<$ PA \uparrow	19.5% and 37.8% of Mexican-born women and men report VPA compared to 40.5% and 62.5% in US-born individuals, corresponding to an odds ratio of 1.9 for both US-born men and women to be more physically active
			1a. Place of birth ^a 1b. Language at home ^b 2. VPA ^c	\rightarrow Supportive (100%, 2/2)	13.8% and 29.7% of Spanish-speaking women and men report VPA compared to 45.3% and 67.2% in English-speaking individuals, corresponding to an odds ratio of 3.5 (women) and 3.0 (men) for English-speaking participants to be more physically active
<p>Notes:^aBorn in Mexico vs. US-born</p> <p>^bOnly Spanish vs. only English at home</p> <p>^cEngaged in VPA (at least 10 min) during leisure time in the past month</p>					
Hofstetter et al. 2008, USA	Representative sample ($n=2,830$, $m=1,265$, $f=1,565$, ≥ 18 years, Koreans, rather young and well-educated sample, California)	Cross-sectional (telephone interviews in preferred language with bilingual interviewer, 86% response rate, controlled for age, gender, marital status, education, BMI, health, smoking)	1. Level of acculturation ^a 2a. VPA ^b 2b. Walking for exercise ^b	Logistic regression Acc. \uparrow $<$ PA \uparrow (2a) Acc. $<$ / $>$ PA (2b) \rightarrow Partly supportive (50%, 1/2)	32.8% of participants reported walking for exercise or vigorous exercise Odds ratio of 1.5 of individuals with high acculturation for reporting VPA compared to individuals with low acculturation
<p>Notes:</p> <p>^a<i>Suinn-Lew Asian Self-Identity Acculturation Scale</i> including cultural preferences related to language, music, food, self-identification, etc.</p> <p>^bNumber of episodes for at least 20 min of vigorous exercise or times per week for walking for exercise, comparison of participants who reported any vs. did not report any exercise</p>					
Hosper et al. 2008, NL	Turkish and Moroccan women ($n=428$, 15–30 years, Amsterdam)	Cross-sectional (random sample, interviews with inter-viewers of the same ethnic background, <i>LASER-study</i> : 2003–2004 data, 57% response rate, controlled for age)	Logistic regression Level of acculturation ^a Sports participation ^b	Acc. \uparrow $<$ PA \uparrow (Turks) Acc. $<$ / $>$ PA (Moroccans) \rightarrow Partly supportive (50%, 1/2)	Odds ratio of 2.1 (Turkish women) and 1.1 (Moroccan women) of individuals with high acculturation for reporting sport participation compared to individuals with low acculturation Greater participation accounted for by more favorable culturally specific beliefs, less perceived disadvantages and higher self-efficacy
<p>Notes:</p> <p>^aUnidirectional acculturation scale (10 items, Dutch orientation scale) including questions about language use, shopping preferences, use of media, difficulties with reading Dutch and emancipation, comparison of upper third with lower two thirds), reliability examined</p> <p>^bParticipation in any sporting activities including unorganized activities defined as being active ≥ 1 day/week for ≥ 30 min with intensity of ≥ 3 MET</p>					

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Mainous et al. 2008, USA	National representative sample ($n=467$, $m=221$, $f=246$, ≥ 18 years, Latino, with previously diagnosed diabetes)	Cross-sectional (random sample, interviews in preferred language, bilingual interviewer, <i>National Health and Nutrition Examination Survey</i> : 1999–2004 data, controlled for age, sex, poverty, education, health insurance, etc.)	Logistic regression 1a. Language preference ^a 1b. Place of birth ^b 2. MVPA ^c	Acc. (1a/b) $</>$ PA → Not supportive (0%, 0/2)	More language-acclimated individuals reported more exercise (59.2% vs. 19.3%). However, this difference was not significant after controlling for possible confounds in logistic regression analysis (despite an odds ratio of 2.2)
Notes:					
^a Short Acculturation Scale, 5 items, validity and reliability established, from Spanish only to English only, comparison of individuals with very low scores (0) compared to the rest of the sample (1–20)					
^b US-born vs. foreign-born					
^c Participation in either moderate or vigorous LTPA, comparison of individuals who participate vs. do not participate					
Martinez et al. 2008, USA	Representative sample ($n=812$, $m=411$, $f=401$, predominantly Mexican children and parents, kindergarten, South San Diego)	Cross-sectional (randomized community intervention, parent-proxy survey in English or Spanish language, study to maintain healthy weights from kindergarten through 2nd grade, 2004–2007: baseline data)	Analysis of covariance 1a. Generational status ^a 1b. Parents' length of residence in USA ^b 1c. Child's language use with parents ^c 1 d. Parents' acculturation ^d 2. Walking to school ^e	Acc. ↑ (1a/b) $<$ PA ↓ Acc. ↑ (1c) $<$ PA ↑ (girls only) Acc. (1d) $</>$ PA → Not supportive (11%, 1/9)	Gradient found for parents' place of birth and length of residence in USA. Girls who speak English with parents are more likely to walk to school than Spanish-speaking and bilingual children. Effect sizes not reported
Notes:					
^a Immigrant status defined on the basis of parents' nativity: Both Mexico-born, mixed status vs. US-born parents					
^b Recent (<12 years) vs. established immigrants (≥ 12 years)					
^c Spanish, bilingual vs. English					
^d Bidirectional acculturation scale (ARMSA-II) including several domains, very Mexican, bicultural vs. slightly Anglo oriented parents, 30 items, validity and reliability established					
^e Days in typical week walking to school or home from school					
Neighbors et al. 2008, USA	Nationally representative sample ($n=104,509$, $\approx 50\%$ women, ≥ 18 years, Hispanics)	Cross-sectional (random sample, interview, <i>National Health Interview Survey</i> : 2000–2003 data, controlled for age, SES, education, employment and health insurance)	Logistic regression	Acc. ↑ (1a/b/c) $<$ PA ↑	Odds ratio of 0.9 (Spanish and English) and 0.7 (Spanish only) of less acculturated individuals for reporting high MPA. Odds ratio of 0.9 (foreign-born) and 0.8 (<10 years of residence) compared to more acculturated immigrants for reporting high MPA Comparable odds ratios found in female and male participants
Notes:					
^a US-born vs. foreign-born					
^b Interview in English only, Spanish and English vs. Spanish only					

Table 2 (continued)

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^c Lived in US ≥10 years vs. <10 years					
^d Light-to-moderate activities during leisure time, comparison of individuals with no MPA, some MPA (below recommendations) vs. above Healthy People 2010 objectives					
Renzaho et al. 2008, AUS	Sub-Saharan African children (<i>n</i> =337, ≈ 50% girls, 3–12 years)	Cross-sectional (snowball sample, stratified by age, gender and region of origin, interviews with parents, controlled for income, education, religion, age, gender, and length of stay)	Multiple regression 1. Level of acculturation ^a 2. LTPA ^b	Acc. ↑ ⇔ PA ↑ (integrated) Acc. </> PA → Partly supportive (50%, 1/2)	Integrated children spent more time in LTPA (137 min) and sedentary behaviors (TV, computer; 241 min) than traditional children (95 and 189 min) No differences in LTPA existed between assimilated, traditional and marginalized children. Compared to traditional children, assimilated children reported more sedentary behaviors
Notes					
^a 15 item index including language, cultural identity, maintenance of traditional diet, participation in cultural events, and media use in heritage language, comparison of traditional, assimilated, integrated and marginalized children by means of median split.					
^b Index included organized sport, leisure activities and home duties outside school hours with intensity levels of ≥3 METs, frequency and duration used to calculate min/day					
Singh et al. 2008, USA	National representative sample (<i>n</i> =68,288, <i>m</i> =35,157, <i>f</i> =33,131, Hispanics, blacks, whites, others, 6–17 years)	Cross-sectional (telephone interviews with parents in English or Spanish language, <i>National Survey of Children's Health – NSCH</i> : 2003 data, 68.8%, controlled for age, sex, household composition, place of residence, education, poverty status, neighborhood safety)	Logistic regression	Acc. ↑ ⇔ PA ↑ (2a/b/c)	Physical inactivity and sedentary behaviors varied widely among children in various ethnic-immigrant groups. Immigrant children in each ethnic minority group generally had higher levels of physical inactivity and lower levels of sports participation than children of US-born parents
			1. Generational status ^a	→ Supportive (67%, 6/9)	Odds ratio of 1.4 (first generation) and 1.5 (second generation) compared to children with third generation background for reporting no PA. Odds ratio of 0.7 (first generation) and 0.6 (second generation) compared to third generation immigrants for reporting regular MVPA. Odds ratio of 1.4 (first generation) and 1.5 (second generation) compared to third generation immigrants for reporting lack of sport participation. Second generation mixed children not different compared to third generation immigrants
			2a. No PA ^b 2b. Regular MVPA ^b 2c. Lack of sport participation ^c		Acculturation particularly influential among Hispanic children. Gender not analyzed as moderator variable
Notes. ^a Immigrant status defined on the basis of children's own nativity and that of their parents: Foreign-born children with foreign-born parents (first generation), US-born children with immigrant parents (second generation), US-born children with 1 immigrant parent (second generation mixed) vs. US-born children with US-born parents (third generation or higher)					
^b Number of days during which the child exercised or participated in MVPA for at least 20 min that made him/her sweat and breath hard, 1 item. Comparison of two categories: a) no days of MVPA, b) regular MVPA (≥3 days of PA)					

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures 1. Acculturation; 2. physical activity	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Chen 2009, USA	Chinese-American children and mothers ($n=65$, $m=32$, $f=33$, $M=8.8$ years (children), $M=38.9$ years (mothers), Chinese, San Francisco)	Cross-sectional (convenience sample, recruited in Chinese community and after-school programs, children who self-identified as Chinese, questionnaires in Chinese and English, controlled for income, and maternal education)	Dichotomous variable (participation vs. no participation) Multivariate regression 1a. Level of acculturation ^a 2a. Mother's LTPA ^b 2b. Caloric expenditure ^c	Acc. \diamond PA (2a/b) → Not supportive (0%, 0/2)	High maternal acculturation was related to low BMI and low sedentary behaviors (TV/computer games), but not to mother's and child's physical activity
Notes:					
^a <i>Suinn-Lew Asian Self-Identity Acculturation Scale</i> , 21 items including language, identity, friendships, behaviors, general and geographic background and attitudes, validity and reliability established					
^b Seven-day PA recall self-reported by mothers including moderate, hard and very hard physical activities					
^c Caltrac accelerometer worn for three consecutive days by the children					
Liu et al. 2009, USA	National representative sample ($n=4,704$, 51% boys, Hispanics, 10–17 years)	Cross-sectional (telephone interviews with children and parents in English or Spanish language, <i>National Survey of Children's Health – NSCH</i> , 55.3% controlled for age, gender, parental education, poverty, child health, parental PA and neighborhood safety)	Logistic regression	Acc. ↑ (1a/1b) \diamond PA ↑	Gradient found that parental PA increases with generational status. 40.7% (first generation), 49.6% (second generation) and 61.7% (third generation) of the parents were classified as physically active. PA higher among parents in families with English as primary language (60.7% vs. 43.6%)
Notes:					
^a Immigrant status defined on the basis of children's own nativity and that of their parents: Foreign-born children with foreign-born parents (first generation), US-born children with at least one immigrant parent (second generation), vs. US-born children with US-born parents (third generation or higher)					
^b Primary language at home (English vs. non-English)					
^c Frequency and duration of MVPA including exercise, sports, and similar aerobic activities that cause sweating and hard breathing. Comparison of individuals who meet MVPA (≥ 3 days/week vigorous activity for 20 min) with adolescents who do not					
Mejean et al. 2009, FRA	Tunisian men ($n=147$, $M=50.2$ years, South of France)	Cross-sectional (quota sampling based on age and place of residence, interviews by French/Arabic bilingual interviewers, controlled for age, economic level and energy intake)	Logistic regression 1a. Length of residence in France ^a 1b. Age at migration ^b 1c. Social ties with home country ^c 2. LTPA ^d	Acc. (1a/b/c) $</>$ PA → Not supportive (0%, 0/3)	Participants with distant social ties with Tunisia had lower occupational PA levels (but not LTPA)
Notes:					
^a Recent (≤ 9 years) vs. more established immigrants (10–29 years, ≥ 30 years)					
^b Young migrants (≤ 20 years) vs. older immigrants (20–29 years, ≥ 30 years)					
^c Index based on remittance behavior for family in the country of origin, language preference, home ownership in Tunisia, having returned to the home country for a holiday during the past year, and projecting to return to the home country after retirement, categories built by means of tertiles					

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
Springer et al. 2009, USA	Representative sample ($n=22,049$, $m=10,938$, $f=11,111$, $M=9.8$, 13.7 and 16.7 years, Hispanics and others, grades 4, 8 and 11, Texas)	Cross-sectional (multistage sampling, survey, <i>School Physical Activity and Nutrition Study: 2004/2005</i> data, controlled for SES)	1. Acculturation; 2. physical activity	Acc. $\uparrow \leftrightarrow$ PA \uparrow	More acculturated girls more active on all PA indicators. Only few differences found among boys. Associations stronger among grade 8 and 11 students compared to 4th graders
			1. Primary language use with parents ^a 2a. VPA ^b 2b. Sports team participation ^c 2c. Other organized PA ^d 2d. Participation in school-based sports vs. sports outside school	\rightarrow Partly supportive (52%, 27/52)	Odds ratios between 1.2 and 1.7 (English-Hispanics) and 1.4 and 2.6 (English-Others) to be classified as physically active compared to Spanish-Hispanic referents among girls. Odds ratios between 1.0 and 1.7 (English-Hispanics) and 1.1 and 2.1 (English-Others) to be classified as physically active compared to Spanish-Hispanic referents among boys
Notes:					
^a Recent immigrants (≤ 10 years) vs. established immigrants (> 10 years)					
^b Participation in any of 21 PAs over the past 3 months					
^c Estimation of total MET equivalents via frequency and duration, active individuals: > 3.0 kcal/kg/day, moderately active individuals: 1.5–3.0 kcal/kg/day, inactive individuals: < 1.5 kcal/kg/day					
^d Any other structured PA such as physical activity-related lessons (e.g. gymnastics)					
Afable-Munsuz et al. 2010, USA	Representative sample ($n=7,896$, ≥ 18 years, Mexican, Chinese, and Filipino adults, California)	Cross-sectional (random sample, interview in preferred language, 2000 US Census and 2005 California Health Interview Survey, controlled for age, gender, marital status, chronic conditions, SES)	Logistic regression	Acc. (1a/b) $\uparrow \leftrightarrow$ PA \uparrow (Mexican)	Odds ratios of 1.4 (third generation) and 1.4 (English and native language) to accomplish minimum LTPA requirements compared to first generation and native language only participants among Mexican participants
			1a. Generational status ^a 1b. Language at home ^b 1c. Interview language ^c 2. LTPA recommendations ^d	Acc. (1c) $\uparrow \leftrightarrow$ PA \uparrow (Chinese) Acc. (1a/b/c) $</>$ PA (others) \rightarrow Not supportive (21%, 3/14)	Odds of 2.4 (interview in English) to accomplish minimum LTPA requirements compared to participants who were interviewed in Chinese
Notes:					
^a Generation one (foreign-born), generation two (born in USA with one or both parents born abroad) vs. generation three (born in USA with both parents born in USA)					
^b English-speaking only, combination of native language and English vs. native language only					
^c English vs. non-English					
^d Recall of last 7 days, comparison of individuals who do vs. do not accomplish minimum PA requirements with LTPA (≥ 3 days of VPA for at least 20 min/day or ≥ 5 days of MPA for at least 30 min/day)					
Dogra et al. 2010, CAN	National representative sample ($n=236,596$, $m=105,984$, $f=130,612$, Whites, South Asians, South-East Asians, Blacks, Latin Americans, merged, controlled for BMI, age,	Cross-sectional (random sample, <i>Canadian Community Health Survey: 2000–2005</i> data, three cycles merged, controlled for BMI, age,	Logistic regression	Acc. $\uparrow \leftrightarrow$ PA \uparrow (2a/c/e/h/g)	All ethnic groups more likely to report no PA and active commuting and less likely to engage in walking endurance, recreation and sport activities compared to whites

Table 2 (continued)

Authors, year, location	Subjects, ethnicity, sample size, age, sample characteristics	Study design (sampling, data assessment, response rate, confounders)	Data analysis, measures	Relationships between acculturation and physical activity	Specific features, moderating influences and strength of relationships
	West Asians, Aboriginals and others)	education and household income)	1. Length of residence in Canada ^a 2a. Walking ^b 2b. Endurance ^b 2c. Recreation ^b 2d. Sports ^b 2e. Conventional exercise ^b 2f. Active commuting ^b 2g. No PA ^b 2h. Total MET (kcal/kg/day) ^c	Acc. ↑ ⇔ PA ↓ (2f) Acc. </> PA (2b/d) → Supportive (75%, 21/28)	Gradient found regarding walking, recreation, exercise, no PA and total MET indicating that non-immigrants are more active than established immigrants, which are more active than recent immigrants. Odds ratio of 1.3 (established females) and 1.3 (established males) and 2.5 (recent males) and 2.9 (recent females) compared to non-immigrants
Notes:					
^a Recent immigrants (≤10 years) vs. established immigrants (>10 years)					
^b Participation in any of 21 PAs over the past 3 months					
^c Estimation of total MET equivalents via frequency and duration, active individuals: >3.0 kcal/kg/day, moderately active individuals: 1.5–3.0 kcal/kg/day, inactive individuals: <1.5 kcal/kg/day					
Ghaddar et al. 2010, USA	Hispanic adults (<i>n</i> =2,381, 78.8% females, ≥18 years, Hispanics, 45% under US poverty level, Arizona, California, New Mexico, Texas)	Cross-sectional (participants recruited from a community health center study, questionnaire or oral interviews in English or Spanish, <i>Alliance for a Healthy Border data</i>)	Logistic regression 1a. Language preference ^a 1b. Country of birth ^b 2a. LTPA recommendations ^c	Acc. (1a) ↑ ⇔ PA ↑ Acc. (1b) </> PA → Not supportive (25%, 1/4)	Odds ratio of 0.8 (low language acculturation) to engage in recommended LTPA compared to participants with moderate or high acculturation
Notes:					
^a Short Acculturation Scale for Hispanics, 5 items, from only Spanish to only English, reliability and validity established					
^b US-born vs. Mexico-/other country-born					
^c BRFSS exercise and PA questions, participants meet MVPA recommendations if ≥3 days of VPA for at least 20 min/day or ≥5 days of MPA for at least 30 min/day, are insufficiently active if MVPA recommendations are not met, and are inactive if no physical activity is reported					
Taverno et al. 2010, USA	National representative sample (<i>n</i> =2,012, <i>m</i> =1,006, <i>f</i> =1,006, <i>M</i> =8.7 years, 6–11 years, Hispanics)	Cross-sectional (random sample, interviews with parents in preferred language by bilingual interviewer, <i>National Survey of Children's Health: 2003 data</i> , controlled for income, education, age, gender)	Logistic regression	Acc. ↑ ⇔ PA ↑ (2a/b)	First generation, non-English speakers were half as likely to engage in regular physical activity and sports compared to third generation, English speakers with odds ratios of 0.5 (VPA) and 0.4 (sports)
Notes:					
^a Generation one (foreign-born), generation two (born in USA with one or both parents born abroad) vs. generation three (born in USA with both parents born in USA), combined with primary language spoken at home, English vs. non-English					
^b Parents reported days/week in VPA for at least 20 min, comparison of children with no physical activity (0 days vs. 1–7 days/week) and regular VPA (0–2 days vs. ≥3 days/week)					
^c Participation on a sports team or taking sports lessons after school or on the weekends in the past 12 months					
Notes: PA physical activity, MPA moderate physical activity, VPA vigorous physical activity, LTPA leisure-time physical activity, SES socioeconomic status, BMI body mass index					

however, were conducted only in approximately half of the studies. Three investigations revealed a closer relationship between acculturation and physical activity among women than men (Abraido-Lanza et al. 2005; Dawson et al. 2005; Martinez et al. 2008).

Ethnicity The relationship between acculturation and physical activity has been most often examined with Hispanic samples (24 studies). Eight studies have focused on Asians. One study was limited to Sub-Saharan African Children (Renzaho et al. 2008). Several investigations used multi-ethnic samples (Dawson et al. 2005; Dogra et al. 2010; Tremblay et al. 2006; Wolin et al. 2006), or recruited individuals from several particular ethnic populations (Afable-Munsuz et al. 2010; Allen et al. 2007; Hosper et al. 2008; Singh et al. 2008; Unger et al. 2004). Some studies were confined to individuals with specific ethnic backgrounds such as Mexicans (Crespo et al. 2001; Dergance et al. 2005; Martinez et al. 2008; Masel et al. 2006; Wilbur et al. 2003), Puerto Ricans (Fitzgerald et al. 2006), Koreans (Choi et al. 2008; Hofstetter et al. 2008; Richman et al. 2000; Song et al. 2004), Turks (Hosper et al. 2007) and Tunisians (Mejean et al. 2009). Partly supporting results were found in Hispanic, Asian, Turkish, North and Sub-Saharan African, and multiethnic samples. Likewise, non-significant findings existed across all ethnic groups. This suggests that ethnic background does not moderate the association between acculturation and physical activity.

Date and source of publication The interest in this topic is fairly recent and started in the 1990s (Pérez-Stable et al. 1994). All studies selected for this review were published in peer-reviewed journals. That is, date and source of publication did not appear to moderate the relationship between acculturation and physical activity.

Sample size With respect to small-scale studies ($n < 500$), supportive and partly supportive findings were found in six investigations (Choi et al. 2008; Hosper et al. 2007; Hosper et al. 2008; Lee et al. 2000; Renzaho et al. 2008; Richman et al. 2000), while eight studies yielded insignificant relationships (Chen 2009; Crespo et al. 2006; Fitzgerald et al. 2006; Mainous et al. 2008; Marquez and McAuley 2006; Martinez et al. 2008; Wilbur et al. 2003; Yang et al. 2007). In studies with sample sizes between 500 and 1,000 participants, four studies were partly supportive (67%), whereas two studies were not supportive (33%). In contrast, of the studies with large sample sizes ($n > 1,000$), eight studies yielded supportive results, eight investigations provided partial support, whereas nine studies were not supportive. Thus, small samples appear to result in an underestimation of effects, while large sample sizes might lead to an overestimation.

Method of data analysis Logistic regression analysis was the most popular method of data analysis (used in 32 of 44 studies). Structural equation modelling (Pichon et al. 2007), linear random modelling (Wolin et al. 2006), linear regression analysis (Chen 2009; Masel et al. 2006; Unger et al. 2004; Yang et al. 2007), analysis of (co)variance (Crespo et al. 2006; Martinez et al. 2008; Richman et al. 2000), correlational analysis (Choi et al. 2008; Marquez and McAuley 2006; Richman et al. 2000) and chi-square testing (Cantero et al. 1999) were used less often. Interestingly, all (fully) supportive findings were based on studies using logistic regression analyses.

Criterion 2: strength of association

In logistic regression analyses, odds ratios provide an indication of the strength of the impact of acculturation on physical activity. While an odds ratio of 1 indicates the same likelihood of an event occurring across two groups, an odds ratio > 1 implies that the event is more likely in the first group. In the literature reviewed, the highest effects were found in the study conducted by Lee et al. (2000) with odds ratios of 4.3 (men) and 7.4 (women) for traditional Korean Americans to report lower light physical activity compared to more acculturated individuals. Fairly high odds ratios (> 2.0) were found in other studies, too (Abraido-Lanza et al. 2005; Berrigan et al. 2006; Corral and Landrine 2008; Dergance et al. 2005; Dogra et al. 2010; Evenson et al. 2004; Hosper et al. 2008; Kandula and Lauderdale 2005; Pérez-Stable et al. 1994; Springer et al. 2009; Wolin et al. 2006). Most of the odds ratios ranged between 1.3 and 2.0 pointing towards a moderate association between acculturation and physical activity. Some studies did not provide odds ratios. Nevertheless, Tremblay et al. (2006) observed a gradient in the prevalence of being physically active showing that recent immigrants (16%) less often reported high physical activity levels than established immigrants (20%), which in turn were less active than non-immigrants (24%).

Criterion 3: specificity of effects

Regarding the measurement of physical activity, support for our hypothesis comes predominantly from studies using general measures of moderate to vigorous physical activity including leisure and non-leisure activities such as exercise, sport, household and gardening activities. Regarding intensity of physical activity, Lee et al. (2000) highlighted that among Korean immigrants, more acculturated individuals reported higher levels of low intensity activity, whereas no relationships occurred for vigorous activities. Studies referring to established physical activity recommendations mostly evidenced partial support (Berrigan et al. 2006;

Evenson et al. 2004; Kandula and Lauderdale 2005; Liu et al. 2009). Concerning sport and exercise participation, support and partial support was found in four studies (Dogra et al. 2010; Hosper et al. 2008; Singh et al. 2008; Springer et al. 2009), while insignificant findings occurred in six investigations (Cantero et al. 1999; Carvajal et al. 2002; Crespo et al. 2006; Fitzgerald et al. 2006; Slattery et al. 2006; Taverno et al. 2010). Specifically, Dogra et al. (2010) found that more acculturated immigrants invest more time in conventional exercise, while no main effect was found for general sport participation. Walking/biking (in the sense of active commuting) was negatively associated with acculturation in two studies (Berrigan et al. 2006; Dogra et al. 2010), while no significant relationships were substantiated in three investigations (Kandula and Lauderdale 2005; Martinez et al. 2008; Pichon et al. 2007). In contrast, walking as a leisure activity appeared to be positively related to acculturation (Dogra et al. 2010; Hofstetter et al. 2008).

Twenty-one studies included separate analyses for two or more acculturation measures, whereas the remaining investigations were limited to one specific indicator. Seven studies have explored the independent influence of participants' place of birth, while most of the research (15 studies) used length of residence as the independent variable. It is noteworthy that the categorization varied markedly between studies. For instance, while some researchers differentiated between immigrants who lived for more/less than 3 years in the USA (e.g. Evenson et al. 2004), others distinguished between individuals who have lived for more/less than 25 years in the host culture (e.g. Cantero et al. 1999), and yet others (e.g. Crespo et al. 2001) used narrower categories in order to examine linear gradients between immigrants with differing levels of acculturation (e.g. born in the host society, < 5 years, 5–9 years, 10–19 years vs. ≥ 20 years). Eight studies used generational status as an indicator of acculturation. Language related aspects of acculturation were assessed in 20 investigations. Language use at home was applied nine times. Additionally, one study combined language use at home and language proficiency (Fitzgerald et al. 2006). Another nine studies used language preferences (often combined with usage). Most of the language preference scales consisted of several items asking about the first language learned, understanding of written English, preferred language at home, with friends or in general and language preference for TV and radio programs. Instruments that provide a broader description of the acculturation experience (e.g. behavioral and subjective elements of culture) and contain a bidimensional/orthogonal approach (independent orientation towards the original and new cultures) have been used less often. Nine studies included unidirectional measures of acculturation (Chen 2009;

Dergance et al. 2005; Hofstetter et al. 2008; Hosper et al. 2007; Hosper et al. 2008; Marquez and McAuley 2006; Pérez-Stable et al. 1994; Unger et al. 2004; Yang et al. 2007). Unger et al. (2004) used the AHIMSA acculturation scale, which draws on a bidirectional approach. However, only the US orientation scale was used to predict physical activity. Seven groups of researchers applied a bidirectional operationalization of acculturation (Carvajal et al. 2002; Choi et al. 2008; Lee et al. 2000; Martinez et al. 2008; Pichon et al. 2007; Renzaho et al. 2008; Song et al. 2004) such as the ARSMA-II scale.

In summary, no clear-cut patterns existed regarding the issue of which acculturation measure is most strongly associated with physical activity. Supportive and partly supportive findings were both found with more objective indicators (place of birth, length of residence, generational status), behavioral constructs (language use) and attitudinal variables (language preference, multidimensional acculturation).

Criterion 4: temporality

To date, only one study (Unger et al. 2004) with 11 year-old adolescents used a prospective design examining how acculturation in grade 6 predicts moderate to vigorous activity in grade 7 (although it did not control for baseline activity). This study did not support our primary hypothesis. The remaining findings were all based on cross-sectional data.

Criterion 5: gradient

Few studies have used a design or strategies of data analyses that allowed the examination of a gradient. Crespo et al. (2001) showed that the odds ratio of less acculturated Mexicans for reporting physical inactivity increased from 1.3 to 1.5, 1.4 and 1.7 compared to US born individuals, depending on whether immigrants have lived ≥ 20 years, 10–19 years, 5–9 years or <5 years in the USA. Similarly, Dawson et al. (2005) showed that among women (but not men) the odds ratios for no regular physical activity increased gradually depending on whether immigrants have lived 15–19 years (1.0), 10–14 years (1.4), 5–9 years (1.7) or <5 years (2.0) in Sweden compared to the most established referents (≥ 20 years). No gradient was found in the remaining studies (Mejean et al. 2009; Wilbur et al. 2003). Moreover, few studies offered combined analyses of two or more acculturation indicators. Fitzgerald et al. (2006) compared Puerto Rican women who spoke only Spanish or were not fluent in English with females who spoke English or were bilingual and who were fluent in English. Although not significant, an odds ratio of 0.5 to be physically active was found for women with low accultur-

ation status compared to females with high scores. Taverno et al. (2010) combined generational status and language usage. Their findings showed that only first-generation immigrants who were non-English speakers had lower odds to report no regular physical activity. For second and third generation immigrants no differences were found as a function of their primary language used at home.

Criterion 6: plausibility

As shown in Table 2, most studies have been sufficiently controlled for confounding variables. Most studies controlled for age, gender and education. Moreover, a majority of studies included one measure of socioeconomic status such as employment status, income, or poverty. Less frequently used variables were marital status, number of children, household composition, language usage, urban/rural residence, having a driving license, parental physical (in)activity, neighborhood attractiveness and safety, health, disability, health related fatalism, drinking, smoking or BMI. Several studies showed that the strength of the association between acculturation and physical activity decreased or became insignificant after controlling for sociodemographic influences (Berrigan et al. 2006; Tremblay et al. 2006; Wolin et al. 2006).

Despite the fact that prior research has identified physical environment as a determinant of individuals' physical activity (e.g. Humpel et al. 2002), few studies have examined perceived environment as a moderating variable. Pichon et al. (2007) found that perceived neighborhood safety/aesthetics did not mediate between acculturation and physical activity. In contrast, Hosper et al. (2007) highlighted that the relationship between acculturation and physical activity was less strong among individuals who had children, lived in less attractive neighbourhoods and who reported high occupational physical activity.

Criterion 7: experimental evidence

To date, no experimental evidence exists showing that acculturation has an impact on individuals' physical activity levels.

Discussion

The main goal of the present review was to examine previous research dealing with the question of whether acculturation leads to changes in immigrants' physical activity levels. From a public health perspective, this issue is highly relevant as prior research has shown that (1) health practices of immigrants may deteriorate after arrival in the host society, and (2) that physical activity is a health-

enhancing behavior that contributes to individuals' physical and mental well-being and prevents the development of chronic diseases such as cardiovascular diseases, cancer, osteoporosis, diabetes mellitus and obesity. Our hypothesis was that individuals would increase their non-occupational physical activity levels as they acculturate to the new society. This relationship would be in opposition to other health (damaging) behaviors such as smoking or alcohol intake, which seem to increase with augmenting acculturation (Pichon et al. 2007).

Nine studies provided support for our hypothesis, whereas 16 investigations were partly supportive. In contrast, 19 investigations were unable to detect the expected effects. In four of these studies, higher acculturation was related to decreased physical activity. In summary, the global analysis showed that 57% of all investigations at least partly supported our hypothesis of a positive relationship between daily and leisure time physical activity. With 19 non-supportive studies, a considerable variability was nonetheless found. This variability was not unexpected given the diversity of sample characteristics, study designs and measurements. Therefore, further criteria were taken into account to determine whether researchers have been successful in demonstrating causal evidence.

Besides the main hypothesis, seven study questions were formulated in relation to Hill's criteria of causal evidence (Hill 1965). That is, consecutive (moderator) analyses were conducted in order to gain deeper insight into the consistency of the findings, the strength of associations, the specificity of effects, issues of temporality, possible gradients, plausibility and experimental evidence. Each of these themes will be discussed separately in the following.

First, the associations are consistent in the sense that significant results were found both in North American and European research and among female and male immigrants. Cross-cultural consistency is important as the sport systems and the meanings ascribed to physical activity, exercise and sport may vary across different cultures (Brandl-Bredenbeck and Brettschneider 1997; De Knop 1998). With regard to gender, most studies on physical activity stress the differences between females and males—in a meta-analytic review of 108 studies, this difference was almost universal and persisted throughout adolescence and adulthood (Sallis et al. 2000). Regarding the process of acculturation, the literature is split on whether the adjustment period is more difficult for men or for women. Some authors claimed that the adaptation period is particularly strenuous for men who often are (or become) the sole breadwinners. Others argued that women more strongly feel the impacts of immigration as they might be forced to enter the job market for the first time in their lives (Stodolska and Alexandris 2004). As our review showed, acculturation seems to positively influence physical activity both among

men and women. Furthermore, researchers have argued that it is easier for children to establish contacts and to assimilate, especially as children who attend mainstream schools have little choice but to interact with mainstream peers (Stodolska and Alexandris 2004). Thus, it was expected that age might impact on how acculturation influences health practices. However, the present review does not support that the associations between acculturation and physical activity depended on participants' age. Nevertheless, studies comparing different age groups are missing. Moreover, the association seemed independent of participants' ethnicity although prior research has shown considerable differences in physical activity related to participants' racial/ethnic background (e.g. Lindström and Sundquist 2001). With respect to methodological influences, studies with large sample sizes more often produced significant results. Sample size affects most tests of significance in the sense that using large samples increases the likelihood of finding significant relationships. Thus, odds ratios are more likely to be significant in large (e.g. $n=1,000$) than small samples (e.g. $n=100$). Our review indicates that sample size moderates the relationship between acculturation and physical activity. Furthermore, all supportive findings were found in studies using logistic regression analyses, in which physical activity was treated as a categorical variable. Thus, even though in most cases information about frequency and duration of physical activity was available and would have allowed the calculation of metric scores, many researchers opted for transforming these values into categorical variables (often with the intention of differentiating between individuals who do/do not accomplish current physical activity recommendations). Perhaps, logistic regressions were best suited to finding support because the relationship between the two constructs is not linear. In summary, neither the host society, age, gender, ethnicity of the participants, the date nor the source of publication had a moderating impact. In contrast, studies with large sample sizes and using logistic regression analyses yielded more supportive findings.

The second question was related to the strength of the relationship between acculturation and physical activity. The odds ratios of more acculturated immigrants for being more physically active mainly ranged between 1.3 and 2.0, although higher odds were found in some studies. Taken together, the relationships between acculturation and physical activity were substantial, particularly as most analyses were controlled for multiple confounds such as age, gender, education and socioeconomic status.

Third, specificity of effects was not demonstrated as various measures of physical activity and acculturation yielded significant findings. To date, almost all findings are based on self-report measures. The only two studies using objective data (Chen and Wu 2008; Marquez and McAuley

2006) did not reveal significant relationships between acculturation and daily step counts. Moreover, the levels of physical activity that researchers considered as 'enough' physical activity varied considerably. For instance, Hosper et al. (2007) classified individuals as active if they engaged in more than 30 min of moderate activity per session at least 1 day/week. In comparison, Carvajal et al. (2002) considered participants as physically active if they have participated more than 4 days in heavy exercise or more than 5 days in lighter exercise. Thus, arbitrary cut-off criteria without reference to current physical activity recommendations complicate the comparison of the findings. Although the measurement of acculturation is still a matter of debate in public health literature, numerous scales are available to measure acculturation. The most commonly used indicators were place of birth/generational status, length of residence in the dominant culture, and language use/proficiency. More recently, these indexes were criticized as insufficient as they cannot capture individual nuances and differences in acculturation and assume a linear trend within the acculturation process. Thus, the underlying assumption of these measures is that adherence to values of the dominant culture increases with higher acculturation. However, this notion has been contested because not all immigrants adopt the values and norms of the majority culture even after a long period of residence in the host society (Stodolska and Alexandris 2004). Moreover, language use and proficiency do not necessarily reflect immigrants' adherence to the values and norms within the majority culture (Hosper et al. 2007), and individuals might acculturate with a different rate in various domains (Lara et al. 2005). Recently, researchers have addressed these issues by developing multidimensional scales tapping different domains such as ethnic identity, language, food, music preferences, and social affiliation with people from the minority or majority culture. The advocates of this approach claim that personal attitudes are key in the acculturation process and that the inclusion of different domains in which people acculturate provides a more grounded reflection of the acculturation process, than a one-sided and arbitrary focus on one specific indicator (e.g. Abraido-Lanza et al. 2006). In summary, the relationship between acculturation and physical activity did not depend on the instruments used to assess acculturation or physical activity. However, the review identified a need for studies, in which acculturation is operationalized in a really bidirectional way, and in which more objective measures are used to assess physical activity.

Fourth, temporality of the effects could not be established as 43 of 44 studies were cross-sectional. Despite the fact that studies using length of residence as an independent variable contain a temporal component, this construct cannot separate individual changes from cohort effects.

Thus, in future studies, researchers should attempt to follow immigrants up over an extended period of time to find out whether increased lengths of residence, language use and the convergence of values towards the dominant culture are in fact accompanied by increased physical activity. Longitudinal research would also allow a more careful examination of mediators that explain how acculturation influences physical activity. In summary, with this limitation in mind, it cannot be determined from past research whether acculturation influences physical activity or vice versa, especially if language and multidimensional acculturation are used as predictor variables.

Fifth, a gradient showing that increased acculturation is paralleled by increases in physical activity was found in two studies. Finding a gradient, however, is complicated by the fact that some studies compared only two categories (Cantero et al. 1999; Dogra et al. 2010; Evenson et al. 2004; Tremblay et al. 2006). Studies looking at interactions between two or more indicators of acculturation (e.g. long time of residence combined with high language proficiency) are missing so far. In summary, the number of studies examining a gradient between acculturation and physical activity is too limited to establish such a relationship.

Sixth, to examine the plausibility of the findings, we have checked whether the analyses have been sufficiently controlled for social and demographic confounds, and whether environmental factors have been considered as potential influences. Controlling sociodemographic factors is important as scientists have argued that acculturation may be a proxy for other variables. For instance, children in immigrant families are more likely than native-born children to be poor, to live in crowded housing, to be uninsured, to lack a source of health care, and to report poor health (Yu et al. 2003). Likewise, English language use is associated with increased parental education, child health, and neighborhood safety, as well as decreased poverty and parental physical inactivity (Liu et al. 2009). It is therefore noteworthy that all supportive studies were sufficiently adjusted for potential confounds. In contrast, attempts to get a better understanding of environmental influences that might moderate the relationship between acculturation and physical activity have been extremely sparse. One study showed that low perceptions of neighborhood safety canceled out the impact of acculturation (Hosper et al. 2007). In summary, previous studies were sufficiently controlled for social and demographic factors, and the findings of this review are based on the adjusted analyses. In contrast, information whether the relationship between acculturation and physical activity depends on environmental factors is largely missing.

Finally, the usefulness of experimental research in this area seems relatively small since acculturation processes are best analyzed in natural settings. With humans, manipulat-

ing or training acculturation is difficult as programs to improve acculturation and integration might appear suspicious to immigrants who presume an assimilationist ideology behind such endeavors. Furthermore, given the tendency towards increasing individualism in Western societies, it remains questionable whether it is realistic to talk about a mainstream culture or if it is necessary to talk about mainstream cultures. Furthermore, changes in individuals' cultural identity develop slowly and might not occur before several years of residence in the host country. In contrast, experimentally manipulating exercise levels is possible. Thus, experimental research seems more suited to address the question of whether physical activity supports the acculturation process among immigrants.

Regarding the mechanisms responsible for association between acculturation and physical activity, several explanations have been offered. Pichon et al. (2007) noted that many recent immigrants arrive from rural or impoverished environments where physical activity might not be encouraged or valued (particularly in women). For instance, the Pan-European study examined attitudes and beliefs surrounding physical activity in 150,239 individuals in 15 countries and showed that Southern Europeans valued physical activity less than individuals living in other European countries (Kafatos et al. 1999). Thus, specific attitudes (e.g. exercise is for young people, exercise is more for men, exercise is only for people who are healthy or really good at it, exercise conflicts with religious beliefs) might prevent some immigrants from being more physically active (Hosper et al. 2008). Springer et al. (2009) for instance found in a study with Hispanic immigrants that cultural values related to modesty (i.e., feeling embarrassed by how one looks in gym attire), machismo (i.e., spouses/partners do not want women to go out and exercise with other men), and familismo (i.e., importance of putting family needs before one's own needs, housework responsibilities) were important barriers preventing regular physical activity. Similarly, Kloetze (2001) reported that married Turkish women in the Netherlands only left the house when they could take their children with them due to responsibility for house and children.

Another underlying assumption is that health-related beliefs or norms concerning particular behaviors change with greater acculturation (Abraido-Lanza et al. 2006). Immigrant families may not be fully aware of physical and psychological health benefits of physical activity and sports participation (Dawson et al. 2005; Singh et al. 2008). Changes in health-related attitudes following immigration, however, have seldom been tested empirically (Abraido-Lanza et al. 2006). Some researchers reported that perception of ideal body weight decreases among more acculturated Latinas (Ayala et al. 2007) and that the wish of having a slimmer figure may become a major motivator for

physical activity. Another explanation assumes that exposure to and perception of health promotion campaigns is greater among people who speak the native language and who have many contacts with the host population (Hosper et al. 2007). Despite this, Unger et al. (2004) warn against the idea that attitudinal changes automatically lead to more healthy behaviors. Rather, adolescents might adopt a preference for activities and foods classified as “Western”, including sedentary activities such as watching TV, playing video games, and eating fast-food. Furthermore, Crespo et al. (2001) lamented that health education materials emphasizing active lifestyles for immigrants are not culturally specific enough or readily available in the minority language.

Finally, researchers have suggested that immigrant parents may lack the time to transport children to structured activities, or the money to pay fees and acquire equipment (Liu et al. 2009), and that, in fact, immigrant parents may discourage their children’s participation in sports because of fear of bullying, linguistic barriers, and the household employment situation (Liu et al. 2009; Yu et al. 2003). Additionally, immigrant parents may place higher value on children’s time devoted to reading and learning activities, language lessons, academic performance, and participation in family activities. Safety concerns are another important consideration that may interact with gender-specific cultural values of heightened parent protectiveness for minority girls (Springer et al. 2009).

The findings of the present review must be interpreted with the following limitations in mind: Establishing a classification system to categorize studies into supportive, supportive and not supportive might seem arbitrary and the conclusion might depend on the categories chosen. Nevertheless, to provide a balanced interpretation, we have decided to classify studies into equally broad categories and to indicate the percentage of supportive findings for each investigation. Furthermore, sample size of the different studies was not weighted although this might rather lead to an under- than overestimation of the results (as studies with small sample sizes yielded fewer significant results). However, it is noteworthy that many studies used (very) large samples. Furthermore, possible publication biases (e.g. non-publication of insignificant findings) cannot be excluded. Moreover, the present review is based on a narrative method of synthesis with the 5% level of significance as a cut-off point. However, Hill’s (1965) criteria of causal evidence allowed a more balanced picture whether there exists support for a causal influence of acculturation on physical activity. Finally, most studies reviewed used proxy measures of acculturation that do not fully reflect an individual’s experience and orientation during the acculturation process. The present study suggests several important avenues for future research. First of all,

research should be extended beyond North America and Europe in order to find out whether acculturation leads to higher physical activity levels in non-Western societies as well. Moreover, researchers should implement prospective or longitudinal designs in order to be able to draw causal conclusions. It seems also desirable to use more objective measures to assess physical activity, to use broad and bidirectional measures of acculturation, and to compare different age groups using the same instruments. Moreover, the gradient between acculturation and physical activity, the interaction of two or more indicators of acculturation, and the factors underlying the association between acculturation and physical activity need further examination.

Conclusion

The results of this review show that nine studies support a positive relationship between acculturation, whereas 19 studies did not find supporting evidence, and 16 investigations provided mixed results. Although 43% of all studies were not able to show significant relationships, the majority of the studies provided at least partly supportive findings. Thus, the findings suggest that efforts to promote acculturation (e.g. language learning) among immigrants might have positive outcomes regarding their levels of physical activity. Additionally, the present findings indicate that intervention programs aimed at stimulating participation in physical activity among immigrants and ethnic minority groups could give priority to those individuals with low acculturation levels (Hosper et al. 2008). For instance, messages promoting physical activity could be tailored to less acculturated immigrants and delivered via channels accessed by these populations including minority-language newspapers, magazines, television, and radio stations (Pichon et al. 2007). Moreover, culturally specific beliefs, needs and constraints could be taken into account when providing activity counseling (Crespo 2000; Hosper et al. 2008). Nevertheless, evidence regarding the effectiveness of such culturally tailored interventions is not established yet. It is our hope that this review will provide the foundation for and stimulate further research on the relationship between acculturation and physical activity.

Conflict of interest statement All authors declare that they have no conflict of interest.

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