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# Acculturation to Western Society as a Risk Factor for High Blood Pressure: A Meta-Analytic Review

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Abstract

**Objective:** A number of studies have documented that acculturation to Western society is related to an increase in blood pressure. Although there is evidence that higher socioeconomic status appears related to better cardiovascular health, increasing acculturation to Western society appears related to worse cardiovascular health. The purpose of this meta-analysis was to investigate the association between acculturation and blood pressure.

**Method:** Literature searches yielded 125 relevant research manuscripts, which were coded by teams of two independent raters. Measures of association (effect sizes) were extracted for both systolic blood pressure (SBP) and diastolic blood pressure (DBP) readings. Random effects models were used to analyze the resulting data.

**Results:** The overall effect sizes associated with acculturation were .28 for SBP and .30 for DBP, with increasing acculturation to Western society related to higher BP. More acculturated individuals had an average of 4 mm Hg higher BP than less acculturated individuals, which is similar to the effect sizes of known risk factors for high blood pressure such as diet and physical activity. The effects of acculturation on BP appear to be universal, with similar effect sizes found across all regions of the world. Change in BP due to acculturation was not related to BMI or cholesterol but was related to length of residence in the new culture, with the largest effect sizes seen upon initial entry and then decreasing rapidly within the first few years. Sudden cultural changes, such as migration from rural to urban settings, resulted in the largest effect sizes, which finding supports the hypothesis that the stress of cultural change is important role in the acculturation effect.

**Conclusions:** Acculturation to Western society is associated with higher blood pressure, and the distress associated with cultural change appears to be more influential than changes in diet or

physical activity.  Future studies would benefit from investigating how cultural change affects health and examining whether some non-Western cultural values and practices are health protective.

**Key Words:** Acculturation, Blood Pressure, Stress, Health Behavior, Meta-Analysis

Acculturation to Western Society as a Risk Factor for High Blood Pressure:

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Researchers have long hypothesized that acculturation to Western society is associated with increases in blood pressure (BP) (1-5). Individuals from Western societies typically have higher BP than those from other regions of the world, with this difference decreasing as non-Westerners adapt to Western culture (6). Immigrants to the United States and Europe from Africa, Asia, Latin America, and Polynesia have consistently shown higher BP with increasing levels of acculturation to Western society (7-10). Industrialization, modernization, and urbanization within non-Western countries (all of which are related to Westernization) are also associated with higher BP levels (7, 11-13).

Although a large number of studies have documented the negative effects of acculturation to Western society on BP (10, 13-14), there is some debate as to why acculturation adversely affects BP (15). Two hypotheses repeatedly cited in the literature state that acculturation to Western society is associated with increase in BP because of 1) stressors associated with cultural change and 2) health behavior changes (diet, physical activity, etc.). Stressors associated with acculturation to Western society include decreased social support and increased job demands (12-13), which factors are consistently associated with higher BP (16). Non-Westerners typically have larger social networks and more social support than Westerners, and as non-Westerners adapt to a Western lifestyle, their level of social support decreases (17). Non-Westerners are less likely to work in stressful job conditions than are Westerners, and adaptation to new styles of work is a potent stressor associated with the acculturation process (13). Another factor related to stress in Western societies is socioeconomic status (SES), with lower SES related to higher BP independent of health care access and health behavior (18-19). Non-

Western immigrants to Western countries have lower SES and lower BP as compared to Westerners (20-21). As non-Westerners acculturate to Western society, however, the SES/BP relationship begins to follow the Western pattern with lower SES related to higher BP (20-21).

Changes in health behaviors associated with acculturation to Western society include poorer diet and less physical activity (5, 15). However, few studies have directly examined changes in diet or physical activity among acculturating populations. Rather, studies have typically examined variables related to diet and physical activity, particularly BMI, cholesterol, and salt intake. Unhealthy changes in diet and physical activity lead to increases in BMI, cholesterol, and salt intake (22). A number of studies have found that increased acculturation is associated these factors (15). Not all studies, however, have found a relationship with acculturation. Salt intake, for example, is not always related to degree of acculturation (13, 23), and at least one study actually found higher levels of salt intake among the less acculturated, lower BP group (24).

Diet and physical activity are traditional risk factors in the development of high BP (22), but stress is not. In their public health announcements organizations such as the National Institutes of Health and the American Heart Association do not include stress as a risk factor for high BP. Recent longitudinal studies, however, have found that changes in stress predict changes in BP. For example, changes in work stress predict changes in BP over time, with increases in work stress predicting higher BP and decreases in work stress predicting lower BP (25). Similarly, changes in financial stress predict changes in BP over time, with increases in financial stress predicting higher BP and decreases in financial strain predicting lower BP (26). In addition, baseline marital distress predicts changes in BP over time, with higher levels of marital distress predicting higher BP (27). In short, distress in any form may increase BP.

Although both distress and health behaviors contribute to increases in BP, some studies indicate that among acculturating populations the distress associated with cultural change may be more significant in predicting increased BP than changes in diet and health behaviors. First, less acculturated groups have lower BP than more acculturated groups, even when negative health behaviors are controlled (8, 13, 23). For example, Japanese immigrants to the United States who continue living a traditional Japanese lifestyle have lower BP than those who acculturate to a Western lifestyle, even after controlling for traditional BP risk factors such as diet and body mass (8). Similarly, Italian nuns, who live a relatively stress free lifestyle, had significantly lower BP as compared to demographically matched Italian laywomen, even though they did not differ significantly in regards to body mass, cholesterol, or salt intake (23). Second, most of the negative impact of acculturation upon BP appears to happen within the first few years of cultural contact (9, 28-29). Samburu tribesmen in Kenya, who have low BP and do not show a rise in BP with age, showed significant increases in BP within three years of joining the Kenyan army, with this change being unrelated to body mass or cholesterol (9). Recently arrived Ethiopian immigrants to Israel have significantly lower BP as compared to Israelis, but after three to four years of residence in Israel, there are no significant differences in BP between the immigrants and the Israelis (28-29). Thus the literature lends some support to the postulate that increased levels of distress among acculturating populations are more strongly associated with increased BP than changes in diet or health behaviors. However, the research literature on the topic of BP and acculturation is quite large, making it difficult to draw any certain conclusions based upon a traditional narrative review.

Although over 100 research studies have investigated the effect of acculturation on BP, no attempts to synthesize this large corpus of research have been made previously. Although this

area of inquiry has many implications for public health (11-15, 22), particularly with acculturation to Western society increasing rapidly across the globe, the only firm conclusion that has been reached in the literature is that a positive relationship exists between blood pressure increases and acculturation. The overall magnitude of that increase remains unknown, particularly across different contexts.

We therefore conducted a meta-analysis (30) to ascertain the strength of the association between acculturation and BP and to examine the influence of contextual factors, such as world region, gender, age, etc., in moderating that association. Furthermore, because some previous studies have indicated that the stress of cultural change appears to be a more central to acculturation effects than changes in health behaviors, we also desired to test that hypothesis through evaluation of relevant variables such as length of residence in the new culture.

Method

*Literature Search*

To identify published and unpublished studies examining the association between acculturation and BP, we used three techniques. First, we conducted searches with several electronic databases: Dissertation Abstracts, HealthSTAR, Medline, Mental Health Abstracts, PsycINFO, Social Sciences Abstracts, and Sociological Abstracts via SocioFile. To capture the broadest possible sample of relevant articles, we used multiple search terms, including the phrase "blood pressure" crossed with a series of search words related to acculturation (all words beginning with the roots *accultur, migrat, immigra, modern, industrial,* and *urban*). To reduce inadvertent omissions, databases yielding the most citations (Medline, PsycINFO) were searched two additional times. Second, we manually examined the reference sections of past reviews and of studies meeting the inclusion criteria for articles not identified in the database searches.

Finally, we sent solicitation letters to authors who had published three or more articles on the topic.

We included in the meta-analysis studies written in English that provided quantitative data on individuals' blood pressure as a function of acculturation to a Western society. We defined acculturation as changes in behavior indicating adaptation to Western society (e.g., acquisition of a Western language) or changes in residence that resulted in increased exposure to Western society, including industrialization, modernization, and urbanization. Qualitative research and single-case designs were excluded from the meta-analysis, but both correlational and comparison group designs were included.

*Data Coding*

To decrease the likelihood of human error in coding data, a team of two raters coded each article. Team members helped one another to verify the accuracy of coding and data entry. Subsequently each article was independently coded by a different two-rater team.

Coders extracted several objectively verifiable characteristics of the studies: 1) the number of participants and their composition by gender, ethnicity, and age if reported; 2) participants' medical/health variables, including average systolic and diastolic blood pressure, blood serum cholesterol levels, and body mass index (BMI); 3) the location of data collection if reported (world region, urban vs. rural); and 4) the type and length of acculturation experienced by participants in the study. In addition, coders evaluated the methodological rigor of the research studies by considering the research procedures and design (i.e., appropriate control groups, adequate measurement and analyses, minimal apparent threats to internal validity). Studies with multiple indicators of methodological rigor were coded "above average" in terms of quality, and studies with multiple methodological limitations were coded as "below average,"

with the remainder coded as "adequate." Average inter-rater agreement was acceptably high, with Cohen's *kappa* being .63 across categorical variables, and intraclass correlation coefficients averaging .81 across continuous variables (31). Discrepancies in the data extracted by the independent teams of coders were resolved by discussion and eventual consensus after computation of inter-rater reliability coefficients.

*Computation of Effect Size Estimates*

To enable meta-analytic analyses, the effect sizes extracted from each study were transformed to the metric of the standardized mean difference (*d*) (32). Data reported in other formats (e.g., Chi-square, correlation, etc.) were transformed to *d* coefficients using the Meta-analysis Calculator software (33). When no statistic was provided but an analysis was reported as significant, we determined the standardized mean difference corresponding to the reported *alpha* level (assuming two-tailed *alpha* = .05 unless reported otherwise). When an analysis was reported as non-significant but no additional information was available, we set the effect size coefficient to *d* = .00. These procedures yielded conservative effect size estimates. The direction of effect sizes was coded uniformly, such that positive values indicated higher blood pressure values as a function of exposure/migration to a different culture and negative values indicated lower blood pressure as a function of exposure/migration to a different culture.

*Analyses*

To aggregate effect sizes and to estimate the reliability of these aggregates, random effects models were calculated using SPSS macros developed by Lipsey and Wilson (30). Rather than use a fixed effects approach, which assumes that every study evaluates the same exact effect, we analyzed the data using random effects models to account for between-studies

variation (34-35). This procedure is therefore more appropriate when attempting to generalize the results beyond the studies included in the analyses (35).

Following the computation of the overall magnitude of the association between blood pressure and acculturation, random effects weighted regression models and analyses of variance (ANOVAs) were conducted to examine the influence of potential moderating variables. Such analyses are useful in determining circumstances under which the strength of the results may vary, in order that a more accurate depiction of the association between blood pressure and acculturation is provided. The level of statistical significance was set at $p \leq .01$ in this study.

## Results

*Descriptive Characteristics*

Statistically non-redundant effect sizes were extracted from 125 studies reported in Table 1 (36-160). Across all studies, data were reported from a total of 223,355 participants. Participant gender and age were reported in 110 (88%) of the studies, with an average of 42% of participants in studies being female and with the average age being 38.6 years. The average participant systolic blood pressure (SBP) was 124.7 across 94 studies, and the average participant diastolic blood pressure (DBP) was 77.1 across 93 studies reporting this information. Studies were conducted across the world, with 33 (26%) in Africa or with African migrants, 29 (23%) in North America, 23 (18%) in Polynesia, 12 (10%) in Asia, 12 (10%) in Europe, 11 (9%) in Central or South America, and 5 (4%) in indeterminate locations.

With regard to research design, the vast majority of studies (77%) involved the comparison of blood pressure readings across pre-existing groups (e.g., a group that had relocated to a Westernized environment vs. a group that had remained in the original location). The remaining studies involved correlational designs (10%), longitudinal survey designs (6%),

quasi-experimental designs (5%), or archival designs (2%). Because of these differences in

research designs and because the quality of research is an important factor to consider in meta-

analyses (30), we conducted preliminary analyses using coders' ratings of methodological rigor.

Most studies (52%) demonstrated adequate research methods, with 35% of studies demonstrating

high levels of methodological rigor and 13% demonstrating methodological limitations. Several

authors caution against excluding studies of questionable quality from meta-analyses if there are

no differences in study outcomes in comparison with apparently more rigorous studies (161,

162). Therefore, we conducted a random effects weighted analysis of variance of effect sizes

across studies of varying methodological rigor. Outcomes did not differ across rated study

quality ($Q_{(2)} = 1.5$, $p = .46$ for effect sizes with SBP and $Q_{(2)} = .85$, $p = .65$ for effect sizes with

DBP). This finding supported the conclusion that the omnibus analyses should be conducted with

the entire set of research studies coded (162).

*Omnibus Analysis*

Omnibus effect sizes were evaluated separately for outcomes related to systolic and

diastolic blood pressure. Across the 124 studies that evaluated systolic blood pressure (SBP), the

random effects weighted average effect size was $d = .28$ ($SE = .023$, $p < .000001$, 95%

Confidence interval = .24 to .33), corresponding to an average difference of 4 mm Hg higher

SBP between acculturated vs. non-acculturated samples. Across the 114 studies that evaluated

diastolic blood pressure (DBP), the random effects weighted average effect size was $d = .30$ ($SE$

$= .025$, $p < .000001$, 95% Confidence interval = .25 to .35), corresponding to an average

difference of 3 mm Hg higher DBP between acculturated vs. non-acculturated samples. Effect

sizes ranged from -.75 to 1.83 for SBP and from -.44 to 1.53 for DBP, with the heterogeneity

across studies being statistically significant for both evaluations of SBP ($Q_{(123)} = 2551$, $p < .001$)

and DBP ($Q_{(113)} = 2415$, $p < .001$), suggesting that systematic effect size variability was unaccounted for. We therefore conducted additional analyses to determine the extent to which the variability in the effect sizes was moderated by other variables.

*Publication Bias*

As a first step, we conducted analyses to evaluate the possibility that the results were moderated by the publication status of the research manuscript. These analyses were essential because of 1) the likelihood for meta-analyses to include greater numbers of published than unpublished studies and 2) the likelihood for published studies to have effect sizes of greater magnitude than those of unpublished studies. Together these two trends can result in *publication bias* in the results of a meta-analysis.

To assess for the possibility of publication bias, we conducted three analyses. First, we plotted a "funnel graph" (163), which is a scatterplot of the effect sizes versus the total sample size of the study. The data obtained from this meta-analysis did conform to the expected inverse funnel shape, indicating that there were apparently few missing studies that would have changed the results. Second, we calculated a fail-safe N (163), which is the theoretical number of unpublished studies with effect sizes averaging zero (no effect) that would need to be located in order to reduce the overall magnitude of the results obtained to zero. Based on this calculation, at least 350 additional studies averaging $d = 0$ would need to be found to render negligible the results of the present meta-analysis. Third, we employed the "trim and fill" methodology described by Duval and Tweedie (164, 165) to estimate the number of studies missing due to publication bias and to recalculate the weighted mean effect sizes accordingly. Using formulae provided by Jennions and Moller (166), the recalculated random effects weighted mean effect size for SBP was $d = .26$ ($p < .00001$, 95% Confidence interval $= .21, .31$) and for DBP it was $d$

= .28 ($p < .00001$, 95% Confidence interval = .23, .33). Based on these three analyses, publication bias seems an unlikely threat to the results.

*Moderation By Participant and Study Characteristics*

To determine whether differences in the gender composition or average age of the participants accounted for significant between-studies variance, we correlated the percentage of females and the average participant age with the corresponding average effect size. Across the studies that examined SBP, the random effects weighted correlation with the percentage of female participants was -.19 ($p = .0034$) and .07 ($p = .32$) with average participant age. Across studies that evaluated DBP, the random effects weighted correlation with percent females was -.21 ($p = .0026$) and .02 ($p = .76$) with average age. Therefore, the results of this meta-analysis were moderated by the gender composition of the sample but not by average participant age. Studies with higher proportions of male participants typically had stronger associations between acculturation and BP.

Several of the studies investigated in this meta-analysis reported average values for participants' health/medical data. Of the kinds of data reported, only body mass index (BMI) and blood serum cholesterol were reported across at least 12 studies (10% of the total number). Random effects weighted correlations between the effect sizes obtained and participants' average BMI values (across 48 studies reporting these data) did not reach statistical significance for neither SBP ($r = .06$; $p = .72$) nor DBP ($r = -.05$; $p = .66$). Similarly, the random effects weighted correlations obtained with blood serum cholesterol levels (across 20 studies) were also not statistically significant for the analyses involving neither SBP ($r = .01$; $p = .99$) nor DBP ($r = .05$; $p = .42$).

Studies typically evaluated the differences in blood pressure associated with one of three kinds of acculturation: 1) adaptation to Westernization/industrialization, 2) migration to a more industrial environment, and 3) adaptation to a host culture.  We therefore analyzed the differences among these three different ways of operationalizing acculturation. As can be seen in Table 2 and Figure 1, those studies that specifically evaluated migration to a more industrial environment yielded a significantly higher average effect size than studies that evaluated other kinds of acculturation.

A related analysis was conducted to determine if the urban/rural composition of the research sample moderated the results.  Given the salience of migration demonstrated in the preceding analysis, populations were categorized into four groups: 1) extant rural sample, 2) extant urban sample, 3) combined urban and rural samples, and 4) migrants from rural to urban locations.  Studies involving participants who were migrants from rural to urban settings had higher SBP and DBP effect sizes than the other groups, with the difference reaching statistical significance for DBP effect sizes (Table 2).

Length of residence in the new culture was also considered as a possible moderating variable.  Length of residence was categorized as being 0-3 months, 3 months to 3 years, 3 to 15 years, and greater than 15 years, with a separate category for studies involving participants who were born in the host culture (and had never migrated).  The results indicate a clear trend for effect sizes that were large upon initial entry in a new culture to decrease over time, with effect sizes among residents of over 15 years being no different than those of participants from a minority ethnic/racial group who had been born in the host culture (Table 2 and Figure 2).

Finally, to determine whether the geographic location of the research sample accounted for significant between-studies variance, we compared studies conducted with participants from

Africa, Asia, Central or South America, Europe, Middle-East, North America, and Polynesia.

Studies from all regions of the world yielded effect sizes greater than zero, indicating that the

acculturation effects are universal; however, among the DBP effect sizes, studies conducted with

participants from the Middle-East had higher average random weighted effect sizes ($d = .49$)

than studies with participants from other regions of the world (Table 2). This finding is likely

due to the fact that 6 of the 10 studies from the Middle-East evaluated recent migrants from

Ethiopia to Israel, with high levels of impoverishment among the migrants and with

correspondingly large gaps between their previous circumstances and the new host society.

<div align="center">Discussion</div>

The main purpose of this meta-analysis was to ascertain the magnitude of the association

between blood pressure and acculturation to Western societies. In the omnibus analysis, it was

found that increased acculturation was related to increased systolic ($d = .28$) and diastolic ($d =

.30$) blood pressure. On average, more acculturated individuals had 4 mm Hg higher SBP and 3

mm Hg higher DBP than less acculturated individuals. The magnitude of the association

between blood pressure and acculturation is comparable to that of established risk factors for

increased blood pressure such as body weight, level of physical activity, and work stress.

Reducing body weight has been associated with about a 5 mm Hg reduction in SBP and 4 mm

Hg reduction in DBP, while increasing physical activity has been associated with about a 5 mm

Hg reduction in SBP and 5 mm Hg reduction in DBP (22, 167-168). With the extensive

attention given to reducing weight and increasing physical activity as means to reduce blood

pressure, it seems clear that issues relevant to acculturation warrant further investigation.

A secondary purpose of this meta-analysis was to examine whether the stress of cultural

change contributed more to changes in BP than changes in health behavior. Two variables

related to obesity and physical activity that were occasionally measured in the acculturation

literature were body mass index (BMI) and cholesterol.  Interestingly, neither BMI nor

cholesterol was related to the acculturation effect.  In fact, the largest effect sizes occur at the

time of initial contact with the new culture and then drop precipitously within the first three years

of acculturation, whereas the effect of acculturation on BP was nonsignificant for those in

contact with the new culture for 15 years or more (Figure 2).  In other words, the majority of the

acculturation effect appears to happen within the first three years of interaction with the new

culture.  Given that BMI and cholesterol are not associated with the differences between blood

pressures of acculturated and non-acculturated groups and that these differences decrease rapidly

following the first few years of cultural contact, it is possible that the distress of cultural change

plays a more important role in the acculturation effect than changes in diet or physical activity.

This conclusion is consistent with several studies that have found a significant acculturation

effect on BP even after controlling for health related variables such as BMI and cholesterol (8-9,

23).

Two additional pieces of evidence provide support for the importance of stress in

acculturation.  First, relocation from rural to urban areas was associated with higher effect sizes

than were other aspects of acculturation (e.g., language acquisition).  Rural groups tend to live

more traditional lifestyles based on communal effort, extended family networks, and higher

social support—all of which can act as buffers against stress (13, 17).  In contrast, urban groups

tend to have lifestyles based on individualistic values and economic competition, with smaller

family networks and less social support—which factors are associated with higher levels of

distress.  Relocating from rural to urban settings can result in distress as migrants try to adapt to

a lifestyle that involves more competition and less social support.

Second, the effect of acculturation to Western societies upon BP was more pronounced in men than in women. Men are usually more negatively affected by acculturation because they are more likely to be in the workplace, which is associated with increased demands and with more constant exposure to the dominant culture (13). Women migrants are more likely to remain in the home, interacting with a network of culturally similar women. By contrast, male migrants tend to have smaller social networks, resulting in fewer social resources to cope with life stressors.

*Future Directions for Acculturation Research and Limitations of Current Studies*

Although it appears that the distress associated with cultural relocation has a major impact on the effect of acculturation on blood pressure, few studies have directly examined this phenomenon. The majority of research studies have focused on the measurement of physiological variables, such as BMI or cholesterol. Ironically, researchers have typically done a poor job at defining and evaluating the kind of acculturation that is occurring, for example, only noting that people have migrated or that an area has become industrialized. Future studies would benefit by more clearly defining acculturation and by using better methods to measure acculturation.

Berry (169) has proposed a comprehensive conceptual framework for defining acculturation based on two key axes. The first axis is the degree to which those acculturating wish to maintain their cultural identity and the second axis is the degree to which they wish to interact with those in the new culture. The interaction of these two axes results in four major types of acculturation: integration, assimilation, separation, and marginalization. Integration is the desire to maintain one's original cultural identity as well as seeking to interact with the new culture. Assimilation is leaving behind one's original cultural identity while seeking interaction

with the new culture. Separation involves maintaining one's original cultural identity while avoiding interaction with the new culture. Marginalization results when there is no desire to maintain cultural identity or to interact with the new culture. It has been hypothesized that integration is the most adaptive and healthiest type of acculturation and future research should be conducted to see if that is indeed the case with respect to changes in BP.

Berry (169) also notes that the stress of acculturation can depend upon a variety of factors in addition to type of acculturation, including characteristics of the new country as well as the country of origin, and demographic, social, and psychological characteristics of those acculturating. Therefore, in regards to the measurement of acculturation, greater care needs to be taken that the measures used accurately assess core constructs of the acculturation process and that the measures can adequately distinguish between cultures (170-171).

Another major limitation in the literature is that the majority of studies have been cross-sectional. Scant data are available on how acculturation and BP covary over time, making it difficult to make any firm statements about causation. Future studies would benefit from using controlled, longitudinal designs that carefully assess both cultural and psychosocial changes, as well as physiological changes. In fact, in this meta-analysis more rigorously conducted studies had larger effect sizes for acculturation.

Although it is known that people in non-Western cultures tend to be more collectivistic and group oriented than those from Western cultures (17), no studies have examined how changes in cultural values or cultural orientation (such as individualism versus collectivism) are related to changes in blood pressure. Some researchers have suggested that more collectivistic cultures have better health because increased social support acts as a buffer against stress (18). It is also possible that the increased achievement orientation and competition found in Western

society will be particularly stressful for immigrants as they attempt to adapt to a new way of life (17). Given that the stress of cultural change appears to be a key factor in acculturation, the assessment of cultural change may be the most fruitful line of research in future acculturation studies.

Studying psychosocial stressors common in Western societies may also be a worthwhile endeavor. Stressors such as social isolation, work stress, and socioeconomic stress are less prevalent in non-Western societies (13); thus they may be particularly stressful for immigrants who have little experience with them. Immigrants tend to have lower SES, greater work related stress, and smaller social networks than those in the majority culture.

Utilizing more accurate methods to assess BP may also improve the quality of the findings obtained in acculturation studies. A large majority of studies of acculturation have used only clinic BP assessment techniques, often relying on only one or two clinic BP measurements. More advanced BP assessment techniques, such as ambulatory blood pressure measurement, would improve the quality and reliability of the data obtained. Additionally, impedance cardiography would make it possible to examine the underlying hemodynamics associated with acculturation. Previous studies have found that a shift in hemodynamics from BP driven by cardiac output to BP driven by increased systemic vascular resistance underlies the development of high blood pressure (172-173). It would be interesting to see if acculturation is associated with increased systemic vascular resistance over time. Another factor implicated in the development of high blood pressure is higher levels of catecholamines, particularly norepinephrine. The Timio et al. study (174) found that norepinephrine was higher among those more acculturated.

*Conclusions*

Acculturation to Western lifestyle is associated with higher BP. BMI and cholesterol are not associated with the acculturation effect, but the stress of cultural change appears to be a major component. Although it appears that acculturation to Western society is a risk factor for increased blood pressure, the processes through which this occurs are still unclear. Future studies would benefit from doing more carefully controlled longitudinal studies of the effects of acculturation on changes in stress, lifestyle, and cultural values.

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Table 1

*Descriptions of the 125 Studies Included in the Meta-Analysis.*

| Study | Participants | N | Effect Size (d) | |
|---|---|---|---|---|
| | | | SBP | DBP |
| Abdul-Rahim 2001 (36) | Urban and Rural | 992 | -0.07 | 0.19 |
| Akinkugbe 1969 (37) | Urban and Rural | 3,058 | 0.28 | 0.28 |
| Baker 1977 (38) | Migrants | 69 | 0.91 | 1.15 |
| Beaglehole 1977 (41) | Migrants | 635 | 0.26 | 0.28 |
| Beaglehole 1978 (39) | Children | 1,117 | 0.27 | NR |
| Beaglehole 1979 (40) | Children | 454 | 0.33 | 0.27 |
| Beiser 1976 (42) | Urban and Rural | 225 | 0.11 | -0.06 |
| Beiser 1980 (43) | Urban and Rural | 456 | 0.00 | 0.00 |
| Benson 1966 (44) | Urban and Rural | 94 | 1.06 | NR |
| Bjerregaard 2002 (45) | Migrants | 3,792 | 0.14 | 0.14 |
| Bongard 2002 (46) | Migrants | 41 | 0.05 | -0.25 |
| Bose 1998 (47) | Migrants | 362 | 0.28 | -0.18 |
| Brown 2000 (48) | Migrants | 31 | 0.32 | 0.12 |
| Brunner 1971 (49) | Migrants | 3,126 | 0.48 | 0.73 |
| Burstyn 1993 (50) | Migrants | 201 | 0.95 | 1.11 |
| Burstyn 1995 (51) | Migrants | 337 | 0.55 | 0.77 |
| Bursztyn 1995 (52) | Migrants | 53 | 0.98 | 0.86 |
| Chasel 1997 (54) | Urban | 118 | 0.38 | 0.26 |
| Cruz-Coke 1964 (57) | Migrants | 179 | NR | 0.25 |
| Cruz-Coke 1981 (56) | Rural | 126 | 0.21 | 0.61 |
| Cruz-coke 1987 (55) | Urban and Rural | 4,195 | 0.35 | NR |
| Dachman 1998 (58) | Urban | 20 | 0.16 | -0.24 |
| Dallo 2000 (59) | Urban | 130 | -0.46 | -0.44 |
| Dash 1994 (60) | Urban and Rural | 3,018 | 0.09 | 0.13 |
| DeStefano 1979 (61) | Rural | 640 | 0.15 | 0.36 |
| Dressler 2000 (63) | Urban | 600 | 0.19 | 0.00 |
| Dressler 1987 (65) | Rural | 147 | 0.82 | 0.72 |
| Dressler 1996 (64) | Rural | 93 | 0.00 | 0.00 |
| Dressler 1997 (62) | Urban | 205 | 0.51 | 0.26 |
| Elder 1998 (66) | Migrants | 277 | 0.19 | 0.21 |
| Elford 1990 (67) | Urban | 3,566 | 0.19 | 0.13 |
| Espino 1990 (68) | Rural | 622 | 0.07 | NR |
| Flemming-Morgan 1991 (69) | Urban and Rural | 158 | -0.44 | -0.37 |
| Florey 1968 (70) | Urban and Rural | 733 | 0.28 | 0.44 |
| Fulmer 1963 (71) | Urban and Rural | 4,208 | 1.06 | 0.91 |
| Gampel 1962 (72) | Urban and Rural | 149 | -0.34 | -0.34 |
| Garcia-Palmieri 1970 (73) | Urban and Rural | 8,785 | 0.37 | 0.39 |
| Gilberts 1994 (74) | Rural | 620 | 0.25 | 0.25 |
| Goldbourt 1991 (75) | Migrants | 530 | 0.16 | 0.63 |

| | | | | |
|---|---|---|---|---|
| Goslar 1997 (76) | Urban | 2,350 | -0.41 | -0.29 |
| Green 1992 (77) | Urban | 5,147 | 0.40 | NR |
| Grossman 1993 (78) | Migrants | 584 | 0.54 | 0.63 |
| Guerrero-Romero 2000 (79) | Urban and Rural | 1,790 | 0.97 | 0.22 |
| Hackenberg 1983 (80) | Urban and Rural | 48,817 | 0.08 | 0.10 |
| Haffner 1990 (82) | Urban and Rural | 5,170 | 0.05 | 0.06 |
| Haffner 1992 (83) | Urban and Rural | 1,462 | 0.00 | NR |
| Haffner 1994 (81) | Urban and Rural | 3,780 | 0.11 | 0.05 |
| Hanna 1979 (84) | Migrants | 386 | -0.29 | -0.07 |
| Hanna 1996 (85) | Urban and Rural | 187 | 0.17 | -0.07 |
| Hansen 1996 (86) | Urban | 119 | -0.25 | NR |
| Harland 1997 (87) | Urban | 1,005 | -0.02 | -0.29 |
| Hawthorne 1969 (88) | Urban and Rural | 461 | 0.07 | -0.41 |
| Hazuda 1996 (89) | Urban and Rural | 1,702 | 0.11 | 0.05 |
| He 1991 (90) | Urban and Rural | 10,513 | 0.36 | 0.47 |
| Hyman 2000 (91) | Urban | 182 | 0.63 | 0.16 |
| James 1989 (92) | Urban and Rural | 123 | 0.24 | 0.65 |
| Janes 1986 (93) | Migrants | 2,353 | 0.68 | 0.76 |
| Jorgenson 1972 (94) | Rural | 1,077 | 0.33 | 0.32 |
| Joseph 1983 (95) | Migrants | 1,851 | 0.16 | 0.20 |
| Kaminer 1960 (96) | Rural | 63 | 1.29 | 0.69 |
| Kaufman 1996 (97) | Urban and Rural | 675 | 0.26 | 0.34 |
| Kaufman 1999 (98) | Migrants | 282 | 0.37 | NR |
| Keil 1977 (100) | Urban and Rural | 214 | -0.32 | 0.10 |
| Keil 1980 (99) | Urban and Rural | 417 | 0.89 | 0.29 |
| Kim 2000 (101) | Migrants | 1,528 | 0.19 | 0.72 |
| Klag 1995 (102) | Urban and Rural | 1,144 | 0.78 | 0.63 |
| Kunitz 1986 (103) | Rural | 1,483 | 0.22 | NR |
| Kusuma 2002 (104) | Urban and Rural | 450 | 0.50 | 0.12 |
| Labarthe 1973 (105) | Urban and Rural | 510 | 0.53 | 0.14 |
| Lewis 1981 (106) | Urban and Rural | 314 | 0.18 | 0.10 |
| Lizarzaburu 2002 (107) | Migrants | 258 | 0.33 | 0.37 |
| Lubree 2002 (108) | Urban and Rural | 441 | 0.28 | 0.60 |
| Malan 1992 (109) | Urban and Rural | 30 | 1.35 | 1.35 |
| Mancilha-Carvalho 1992 (53) | Rural | 254 | 0.39 | 0.31 |
| Mugamer 1995 (110) | Urban and Rural | 322 | 0.18 | 0.00 |
| Mukhopadhyay 2001 (111) | Urban and Rural | 346 | 0.06 | 0.23 |
| Murphy 1994 (112) | Urban and Rural | 142 | -0.75 | 0.00 |
| Nadim 1978 (113) | Rural | 1,139 | 0.49 | 0.84 |
| Nirmala 2001 (114) | Urban and Rural | 1,184 | 0.54 | 0.64 |
| Norman-Taylor 1963 (115) | Rural | 713 | 0.12 | -0.10 |
| Okosun 1999 (116) | Urban and Rural | 8,982 | 0.05 | 0.28 |
| Osei 1996 (117) | Migrants | 58 | 0.37 | 0.79 |
| Padmavati 1959 (118) | Urban and Rural | 691 | 0.19 | 0.07 |
| Page 1974 (119) | Rural | 1,235 | 0.42 | 0.23 |
| Patrick 1983 (120) | Urban and Rural | 723 | -0.26 | -0.03 |
| Pavan 1997 (121) | Urban and Rural | 740 | 0.70 | 0.98 |
| Poulter 1990 (123) | Migrants | 637 | 0.78 | 0.87 |
| Poulter 1984 (122) | Urban and Rural | 1,473 | 0.13 | 0.22 |
| Poulter 1985 (124) | Urban and Rural | 1,181 | 0.46 | 0.64 |

| | | | | |
|---|---|---|---|---|
| Prior 1968 (125) | Urban and Rural | 822 | 1.28 | 1.06 |
| Proctor 1996 (126) | Children | 88 | 0.22 | 0.26 |
| Reddy 1994 (127) | Urban and Rural | 380 | -0.06 | 0.24 |
| Reed 1970 (128) | Urban and Rural | 1,214 | 0.04 | 0.07 |
| Rosenthal 1990 (129) | Migrants | 5,577 | 0.68 | 0.70 |
| Salmond 1985 (130) | Migrants | 812 | 0.02 | 0.11 |
| Salmond 1989 (131) | Migrants | 251 | 1.83 | 1.53 |
| Seedat 1982 (132) | Urban and Rural | 1,936 | 0.17 | NR |
| Sever 1980 (133) | Urban and Rural | 251 | 0.39 | 0.52 |
| Sharper 1969 (134) | Military Group | 60 | 1.08 | 0.42 |
| Sherman 1998 (135) | Students | 68 | 0.85 | 0.72 |
| Silman 1987 (136) | Migrants | 772 | 0.22 | 0.17 |
| Sobngwi 2002 (137) | Urban and Rural | 2,465 | 0.17 | 0.08 |
| Somova 1995 (138) | Students | 2,902 | 0.14 | NR |
| Taylor 1991  (140) | Migrants | 1,024 | -0.08 | 0.17 |
| Taylor 1987 (139) | Migrants | 1,143 | 0.22 | 0.22 |
| Taylor 1989  (141) | Urban and Rural | 2,632 | 0.09 | 0.17 |
| Taylor 1999 (142) | Urban and Rural | 94 | -0.10 | 0.12 |
| Timio 1997 (143) | Urban and Rural | 282 | 0.44 | 0.44 |
| Tomson 1994 (144) | Migrants | 3,449 | 0.42 | 0.35 |
| Torun 2002 (145) | Migrants | 473 | 0.00 | 0.04 |
| Tracy 1999 (146) | Urban | 553 | 0.54 | 0.54 |
| Tsugane 1989 (147) | Migrants | 584 | 0.30 | 0.24 |
| Ulman 1975 (148) | Migrants | 12,692 | 0.16 | 0.15 |
| Van den Hoogen  2000 (149) | Urban | 4,893 | 0.35 | 0.39 |
| Van Rooyen 2002 (150) | Urban and Rural | 223 | 0.64 | 1.07 |
| Van Rooyen 2000 (151) | Migrants | 1,821 | 0.14 | 0.22 |
| Villela 2000 (152) | Rural | 81 | -0.19 | -0.02 |
| Walsh 1980 (154) | Migrants | 75 | 0.52 | 0.77 |
| Walsh 1986 (153) | Urban | 137 | -0.32 | -0.60 |
| Ward 1980 (155) | Migrants | 1,061 | 0.20 | 0.18 |
| Wilks 1996 (156) | Urban and Rural | 8,488 | 0.11 | 0.19 |
| Williams 1993 (157) | Migrants | 159 | 0.00 | 0.00 |
| Zerba 1990 (158) | Rural | 3,249 | 0.23 | -0.02 |
| Zimmet 1980 (159) | Urban and Rural | 306 | 0.17 | 0.30 |
| Zimmet 1980  (160) | Urban and Rural | 1,488 | 0.53 | 0.48 |

Note.  N = number of participants.  $\underline{d}$ = standardized mean difference. SBP = Systolic blood pressure.  DBP = Diastolic blood pressure.  NR = Not reported.

Table 2

*Random Effects Weighted Mean Effect Sizes (d) Across Levels of Several Moderator Variables in Studies Evaluating Blood Pressure in Association with Acculturation.*

| Variable | Systolic Blood Pressure | | | | Diastolic Blood Pressure | | | |
|---|---|---|---|---|---|---|---|---|
| | $Q_b$ | p | k | d | $Q_b$ | p | k | d |
| Measurement of Blood Pressure | 4.9 | .03 | | | 4.7 | .03 | | |
| Single Reading | | | 29 | .37 | | | 26 | .39 |
| Multiple Readings (averaged) | | | 88 | .24 | | | 80 | .26 |
| Type of Acculturation Evaluated | 11.2 | .003 | | | 11.4 | .003 | | |
| Westernization/Industrialization | | | 69 | .22 | | | 60 | .26 |
| Migration to a Western Society | | | 34 | .40 | | | 33 | .43 |
| Adaptation to a Host Culture | | | 10 | .28 | | | 9 | .20 |
| Rural/Urban Population Groups | 6.9 | .07 | | | 19.7 | .0002 | | |
| Rural | | | 11 | .24 | | | 10 | .29 |
| Urban | | | 14 | .15 | | | 12 | .02 |
| Combined Rural/Urban | | | 54 | .26 | | | 50 | .27 |
| Migrants from Rural to Urban | | | 27 | .37 | | | 27 | .44 |
| Length of Acculturation | 23.9 | .0001 | | | 24.9 | .0001 | | |
| 0-3 months | | | 6 | .66 | | | 6 | .65 |
| 3 months to 3 years | | | 7 | .52 | | | 8 | .57 |
| 3 years to 15 years | | | 15 | .38 | | | 14 | .33 |
| More than 15 years | | | 31 | .23 | | | 27 | .22 |
| Born in the host culture | | | 41 | .27 | | | 40 | .29 |
| Region of Data Collection | 11.0 | .09 | | | 20.7 | .002 | | |
| Africa | | | 21 | .32 | | | 18 | .36 |
| Asia | | | 12 | .24 | | | 12 | .30 |
| Central/South America | | | 14 | .33 | | | 14 | .27 |
| Europe | | | 13 | .36 | | | 11 | .13 |
| North America | | | 30 | .18 | | | 26 | .22 |
| Middle-East | | | 10 | .48 | | | 10 | .65 |
| Polynesia | | | 21 | .32 | | | 19 | .30 |

Note.  $Q_b$ = Q-value for variance between groups.  This statistic is comparable to the F-value in ANOVAs.   k = number of studies.  d = standardized mean difference, the effect size used in this meta-analysis to indicate the magnitude of differences in participants' blood pressure as a function of acculturation.

**Magnitude of Effect Size (d) by Type of Acculturation Evaluated**
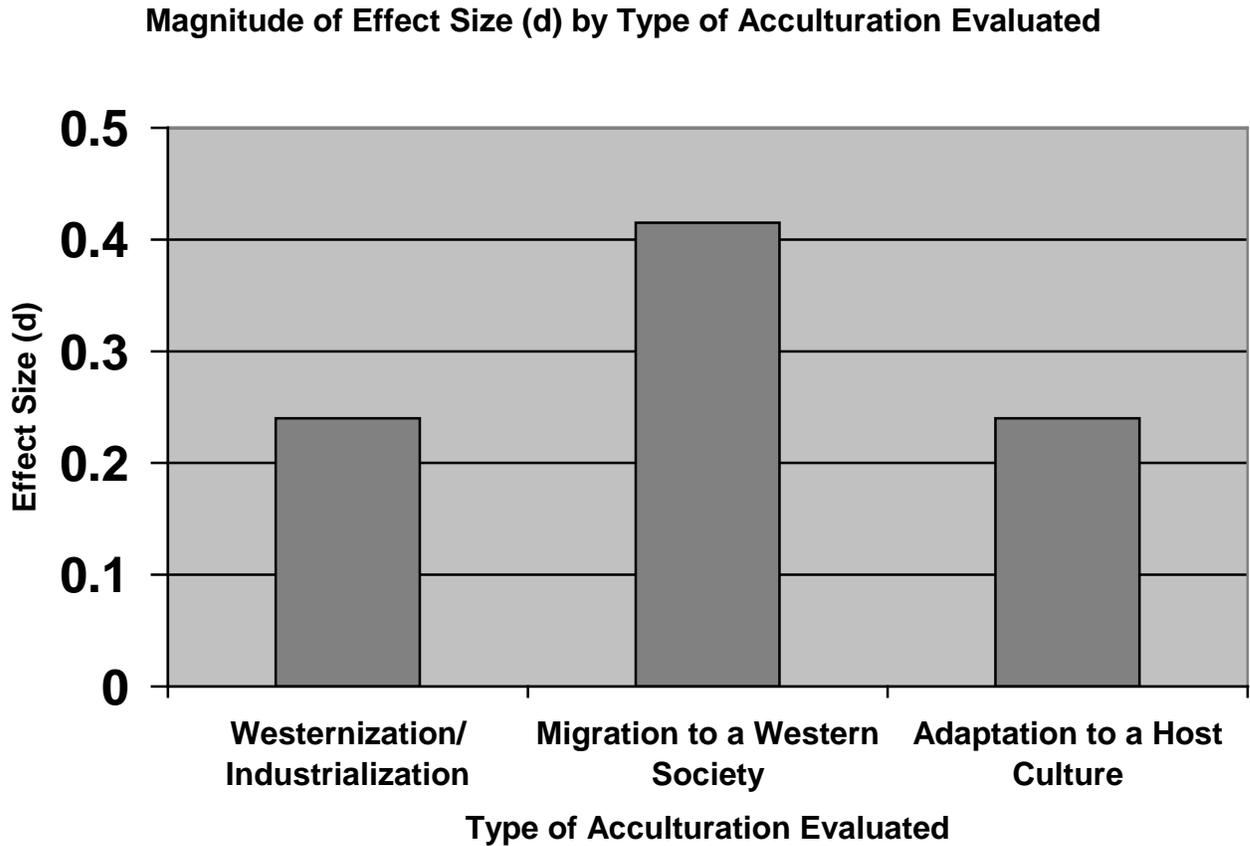


Figure 1. The largest effect sizes for acculturation on blood pressure were found among non-Westerners who migrated from their country of origin to a Western society, indicating that large cultural changes are strongly associated with increases in blood pressure.

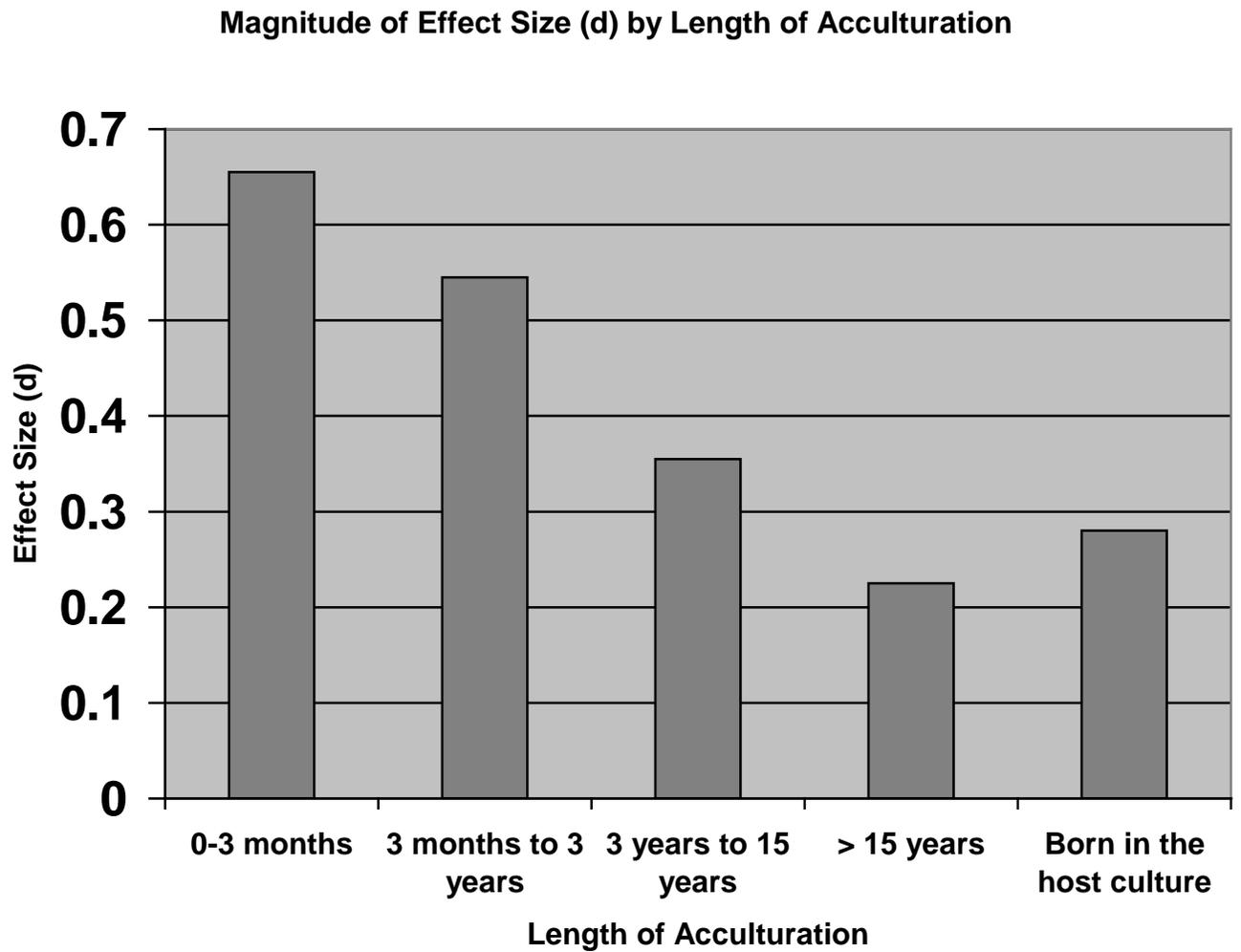**Magnitude of Effect Size (d) by Length of Acculturation**



Figure 2. The largest effects sizes for acculturation on blood pressure were observed within 3 years of acculturating. This provides support to the hypothesis that the stress of cultural change plays a significant role in the acculturation process.